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FOREWORD

The Government of Japan, in response to the request from the Government of the Jalisco State in United Mexican States, entrusted to the Overseas Technical Cooperation Agency (OTCA) the task of conducting the survey of urban transportation in Guadalajara City, the capital of Jalisco State.

The OTCA organized a five-member team of experts, headed by Mr. Hiroshi Takeda (Deputy Director, Tokyo Construction Bureau, Japanese National Railways), as a mission assigned by the Government of Japan under the Technical Cooperation Plan for Latin America.

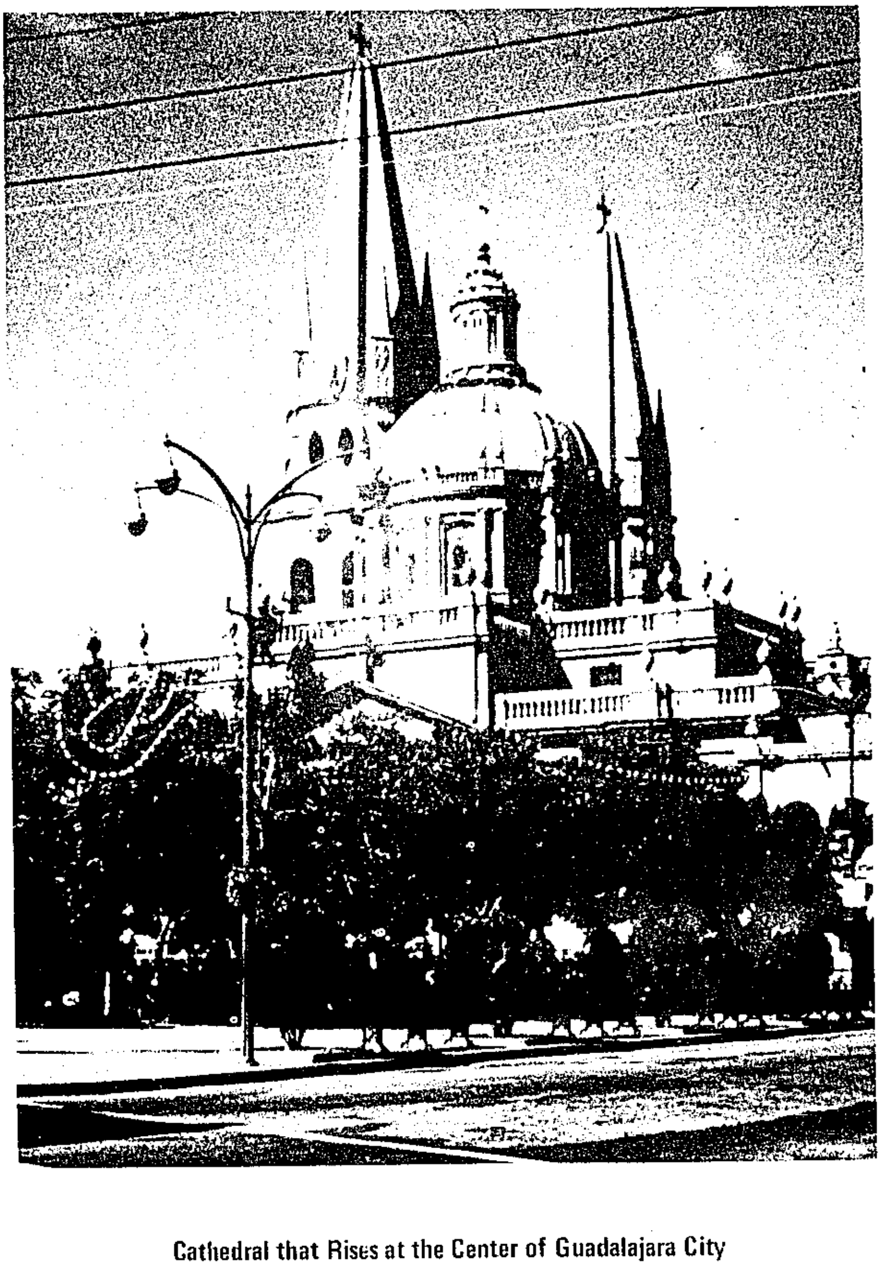
The expert team was despatched to Mexico on December 10, 1968 for a month and a half. The survey, though for a short period, was carried out with a view of formulating plans for the traffic facilities adapted to the actual situation. Now, we have come to the stage of presenting a report to the Government of the Jalisco State in United Mexican States.

It is our sincere hope that this report will be not only of some service on pushing forward the development of urban traffic facilities in Mexico, but also plays a part in the promotion of friendly relations between Japan and Mexico.

On this occasion, we wish to express our heartiest thanks to all the members of the team who conducted the survey, Japanese Embassy which rendered cooperation at the survey site, the Ministry of Transport, Japanese National Railways, Tokyo Metropolitan Government, TEITO Rapid Transit Authority and other organizations concerned which offered cooperation in assigning the survey team.

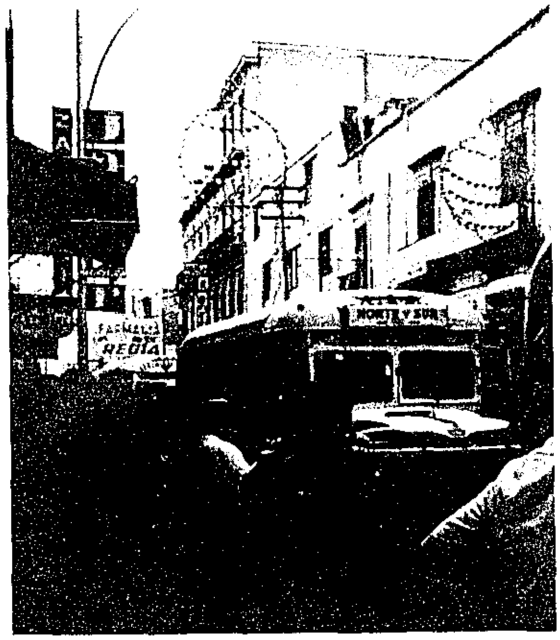
July 1969

Shin-ichi Shibusawa
Director-General



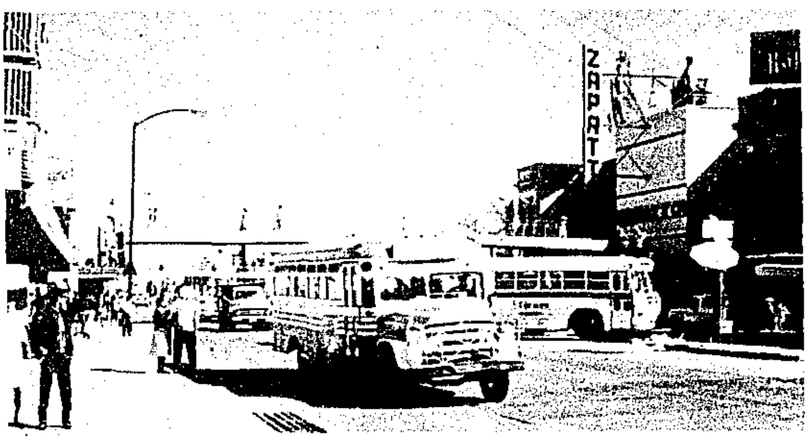
Cathedral that Rises at the Center of Guadalajara City

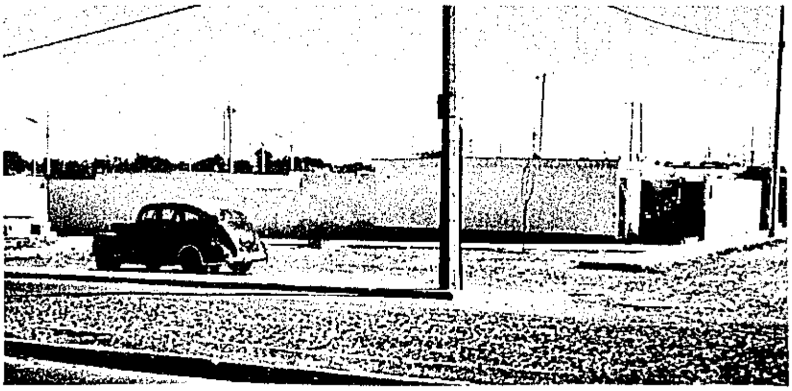
Avenida Juarez, Main Street of the City
Running from East to West



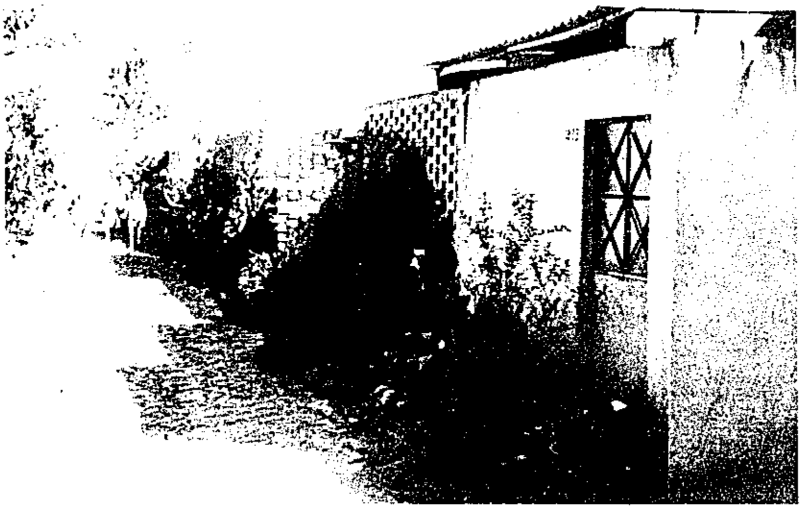
Narrow Road of Morelos Street Congested with Buses

Calzada Independencia, the Artery Connecting the North and the South



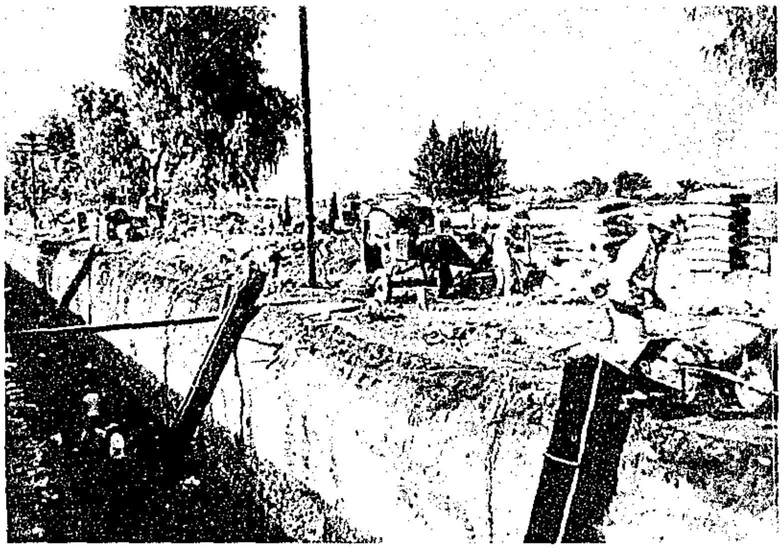


Suburban Residence in Tlaquepaque District

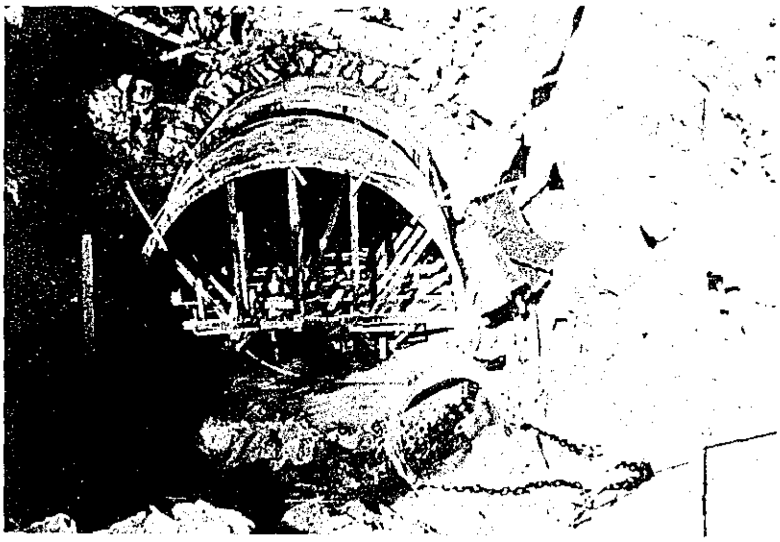


Ordinary Suburban Residences in the South

Avenida Las Americas, in the Upper-Class Residential Area



Main Drainage Works on Lopez Mateos Street in the South-Eastern Part of the City



Excavation and Stone Masonry Works for Main Drainage in the Rock Formation in the North-Western Part of the City

Investigation Team Head Explaining the Summary of the Intermediate Report to Jalisco State Governor Lic. Medina Ascensio (Center) and Arq. Navarro Franco (Left) who Visit the Office of Investigation Team

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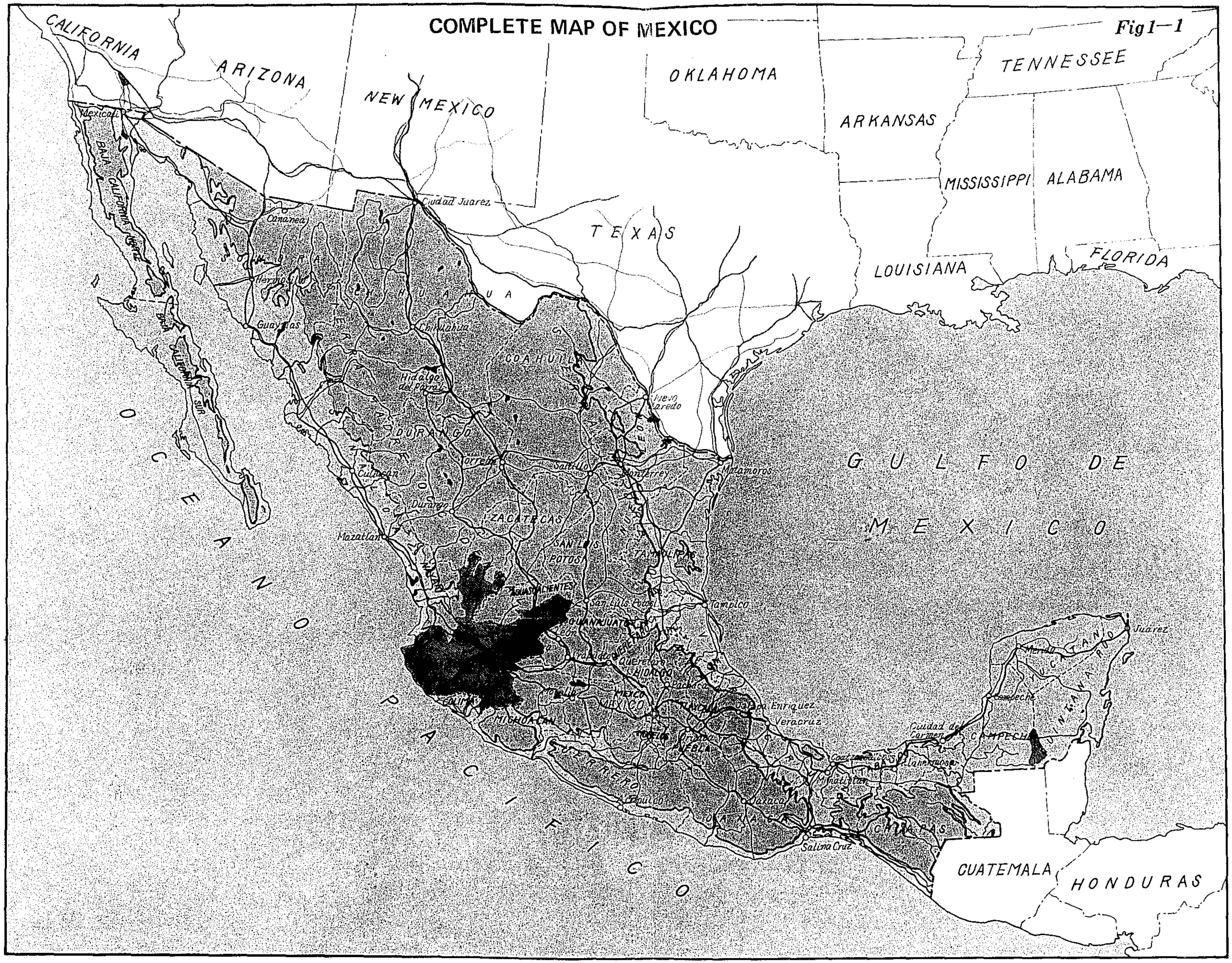

COMPLETE MAP OF MEXICO

Fig 1—1

CHAPTER 1. GENERAL

1. Preface

1) The formation and purpose of the investigation mission

Since the Mexican Revolution of 1910, United Mexican States has made a remarkable growth as a modern state with its rapid economic development.

In recent years, however, there is rapidly growing concentration of population in the major cities of Mexico as in the big cities of other countries and the urban transport system, which has depended solely upon automobiles, is now in a state of being saturated with traffic. This state of things is observed in such big cities as Mexico City, Monterray and Guadalajara.

In Mexico City, the capital of Mexico, a plan was formulated in 1965 to construct a subway network and work went under way immediately so that the new subway system is expected to go into operation very soon.

Guadalajara, the second largest city in Mexico, has a population of 1,400,000. Although its population is still much less than that of Mexico City, it is expanding rapidly at an annual rate of more than 8 per cent with the result that the city has tremendous traffic congestion during the rush hours in an increasing number of sections.

In an effort to solve this problem, Lic. Francisco Medina Ascencio, Governor of State of Jalisco, set his eyes on the technical knowledge and skill of Japan which had already sent an urban transport investigation mission to many countries of Central and South Americas and requested the Japanese Government through the Japanese Embassy in Mexico to send an investigation mission to his country as stated below.

Guadalajara City the capital of Jalksco State having 1,200,000 inhabitants at present is second largest city in United Mexican States, and is increasing its population at the rate of 8% per year. This explosive development is causing many troubles in the urban transportation of the city, and the problem should be settled immediatley by setting up the new transportation facilities, such as Subway, Trolley buss or Mono-Rail. In order to adopt a concrete plan of the new transportation system, the Government of Jalisco State would like to have a cooperation from Japan, by receiving a survey mission which will study and investigate on the transportation troubles, and give the technically, and economically recommendable transportation system to be set up in the very near future. And after the decision of concrete plan, the Government further would like to have the cooperation from Japan to realize this project by supplying material, equipment and engineering from Japan.

On receiving the request, the Japanese Government determined to send an investigation mission to Mexico as a link in the chain of its program of extending technical cooperation to the Latin American countries, and requested the Japan Overseas Technical Cooperation Agency to undertake the project. The Agency in turn asked the Railway Supervision Bureau of the Ministry of Transportation to select suitable persons to form the investigation mission to be sent to Mexico.

As shown in the above request, the purpose of the investigation mission was to make investigations of the urban structure, demography, physiology, topography and geology of Guadalajara City to find out an urban mass transport system best suited for the city and make the most practical city transport plan while taking into consideration on the future traffic requirements of the city, and submit the prepared report to the Government of Jalisco State.

The report was made in two installments–the intermediate report made in Mexico and the final report after the return of the mission to Japan.

The intermediate report gave only the broad outline of the results of investigation because of the limited time and personnel that were available in Mexico. The intermediate report was submitted to Governor of Jalisco State on January 13.

After returning to Japan, the mission made a careful study of the extensive materials obtained while staying in Guadalajara City and analyzed the various problems of the urban traffic and transport system of the city, using the knowledge of the urban transport system in various cities of the northeastern region of the U.S.A. visited on its way home, and prepared its final report containing the basic plan for the recommendable urban transport system, and the design, construction and management of it, for submission to the Government of Jalisco State through the Japanese Embassy in Mexico.

2) Composition of the investigation mission

The mission, headed by Mr. Hiroshi Takeda, deputy director of the First Construction Department of Tokyo, the Japanese National Railways, was composed of five experts in city planning, urban transportation, surface and underground transport systems, as listed below.

Chief ······················ Mr. Hiroshi Takeda
Deputy Director of First Construction Department
of Tokyo, Japanese National Railways

Member	Mr. Susumu Taniguchi Chief of First Sub-section of Public Facilities, Second City Planning Division, Capital City Development Bureau of Tokyo Metropolis
Member	Mr. Rokuro Inoue Deputy Chief of Second Station Section, Construction Department, Japanese National Railways
Member	Mr. Satoru Hara Special Assistant to the Chief of the Urban Transport Section, Secretariat to the Minister, Ministry of Transport.
Member	Mr. Minoru Arai Engineer of Second Designing Section, Construction Headquarters, Teito Rapid Transit Authority

The following engineering expert assisted in the making of the present report after the return to Japan of the investigation mission from Mexico.

Akio Kawasaki	Chief of Machine Section, First Construction Department of Tokyo, Japanese National Railways

3) Cooperation given by the Government of Jalisco State and other public organizations concerned

The investigation mission was provided with the following convenience by the Government of Jalisco State.

Interpreter-translator (Spanish - English)	4
Office Room	2
Automobile	2

The drivers of the cars that were placed at the disposal of the mission were uniformed policemen and this proved very advantageous for the mission. Since the subjects of investigation were in the jurisdictions of several departments of the Government of Jalisco State, a meeting of the chiefs of all the departments concerned were held once a week as proposed by the chief of the economic department.

We were fully satisfied with the convenience given to us and very much impressed with the great willingness of the Government of Jalisco State and other public organizations concerned to cooperate with us. Taking this oppportunity, we acknowledge especially the kind help of the following persons.

Economic Department

Chief	Lic. Juán Delgado Navarro
Representative	Lic. Sixto Gorjón Mascareñas
General Coordinator	Arq. Guillermo Navarro Franco

Office Inventory Resource

Chief	Ing. Ramón Hanon Montero

Public-works Department

Chief	Arq. Guillermo Quintanar Sualegui
Deputy Chief	Arq. Humberto Ponce Adame
Deputy Chief	Ing. Juán Jiménez Romo

Traffic Department

Chief	Mayor Alfrode Medina Guerra
Representative	Ing. Alfonso Lozano Gallo

Public Relations Department

Chief	Ing. Rubén Rios Ahumada

Jalisco State Urbanization and Planning General Council

Chief	Arq. Eduardo Ibanez
(Project Office Chief)	
Coordinator	Arq. Guillermo Navarro Franco
Coordinator	Arq. Daniel Vázquez Aguilar

Public-works Department and Municipal Service

Chief	Ing. Rector Luna Arias

Department of Technology, Guadalajara University

Dean	Ing. J. Jesús Moncayo
	Ing. Javier Saborio Ulloa
	Ing. José Abel Salazar

We are also grateful for the geat services given to us by the following persons who accompanied us as interpreters everywhere we went during our stay in Mexico.

Sra.Dolores de Wenee
Srita.Olga Estela Lozano
Srita Sumako Yamamoto
Sr. Ricardo Makoto Yanome

4) Itinerary of the investigation mission

The investigation mission left Japan from the Tokyo International Airport on December 10, 1968 and arrived in Mexico City on the 11th of the same month. After making necessary arrangements at the Japanese Embassy, the mission accompanied with Commercial Attaché Okane arrived in Guadalajara City on December 12. The mission started its activity after making arrangements on the details of its investigatory work in the conference room of the Jalisco State Planning Department the next day. The mission made investigations in and around the city, gathered necessary informational materials and had discussions during a period of one month or so. On January 13, 1969, the mission submitted its intermediate report to the Governor of Jalisco State and left the city. It arrived in Mexico City on January 14 and inspected the work presently under way on a subway system. In order to have additional knowledge of the subway systems in the cities of the Northeast of the U.S.A. in relation to the study of the urban transportation of Guadalajara, the investigation mission split into two groups and left Mexico City for the U.S.A. on January 16. One group toured to Boston, Philadelphia and New York and the other to Chicago and New York. The mission returned to Japan on January 23 via San Francisco. The itinerary of the mission was as follows.

December of 1968

10 (Tue.) Left the Tokyo International Airport and arrived in Los Angeles.

11 (Wed.) Left Los Angeles and arrived in Mexico City.

12 (Thu.) Made necessary arrangements on the work of the investigation at the Japanese Embassy and arrived in Guadalajara City.

13 (Fri.) Had the first meeting on the urban transport system with the officials of Jalisco State with Commercial Attaché Okane in attendance.

14 (Sat.) Inspected the traffic situation and urban environmental conditions of Calzada Independencia, Av. Vallarta, Av. Javier, Cuidad Granja, and Prados Vallarta.

15 (Sun.) Holiday

16 (Mon.) Inspected the traffic situation and urban environmental conditions of Av. López Mateos, Las Fuentes, Colonia del Sur, and Zona Industrial, and the only bus terminal in the city.

17 (Tue.) Inspected the traffic situation and urban environmental conditions of Av. Alcalde, Calzada Maneul Avila Camacho, Zapopan, Zoquipan, Atemajac, Av. Las Americas, and Chapultepec Country.

18 (Wed.) Met Arq. Guillermo Navarro to make additional questions and urge him to provide needed informational materials at the earliest possible time. Heard the explanations on the city planning of Guadalajara given by Arq. Navarro and Arq. Vazquez at the Planning Department of Jalisco State.

19 (Thu.) Made a study on the drawings of city planning of Gradalajara and heard explanations given by Ing. Lozano Gallo, Deputy Chief of Traffic Department in the office.

20 (Fri.) Had the second joint meeting with the attendance of the chief of the departments concerned. Obtained some materials. Told that the rest of the required materials would be made available within a week. It was agreed at this meeting that Arq. Navarro would thereafter act as the general representative of the Mexican authorities and he would be responsible for gathering all necessary informational materials from the governments of Jalisco State and Guadalajara City and private business organizations.

21 (Sat.) Made a study on the collected materals in the office during the morning. Spent the afternoon inspecting the construction of residential houses in the southern suburb of the city.

22 (Sun.) Holiday

23 (Mon.) Inspected the main sewerage presently under construction in Av. Lopez Mateos. Heard explanations given by Arq. Guillermo Quintanar and Arq. Ponce Adame on the nature of the soil, cement, concrete, reinforcing steel, cost of labor and other matters concerning the construction project.
Spent the afternoon in studying the materials gathered during the morning.

24 (Tue.) Studied and processed the obtained data in the office throughout the day.

25 (Wed.) Christmas holiday

26 (Thu.) Visited Guadalajara University and heard explanations given by Ing. Moncayo, Dean of Department of Technology, and Ing. Javier, Moreno, Professor, on the nature of the soil and the foundation work for the main buildings in Guadalajara City. Inspected the traffic situation and urban environmental conditions of Hacienda de Huentitan, Sn. Martin, and Circunvalación

Belisario.

27 (Fri.) Ing. Jiménez Romo visited our office to explain to us about the sewerage system construction work in the city. Had the third joint meeting, where the following four films brought by the mission from Japan were shown.

(1) The New Tokaido Line
(2) Railway-bridge of Light-weight Concrete
(3) Revelution of Urban Transportation, Monorail
(4) Subways in Tokyo

28 (Sat.) Inspected the housing situation, urban facilities and traffic situation in Hidalgo Providencia and Lomas del Valle.

29 (Sun.) Holiday (Inspected the traffic situation and urban environmental conditions in and around Tlaquepaque.)

30 (Mon.) Started formulating a plan for the proposed subway system in our office in the morning. In the afternoon, Ing. Lozano Gallo visited our office and exchanged views on the problem of traffic with reference to the statistical diagrans of traffic.

31 (Tue.) Dr. Luther Garcia visited our office and explained to us about the subway construction project in Mexico City.

January of 1969

1 (Wed.) New Year's holiday

2 (Thu.) Spent the whole day in our office making the final study of the collected informational materials. Exchanged views with Arq. Navarro on the subjects to in the intermediate report during the evening.

3 (Fri.) Visited Banco de Comercio de Guadalajara, accompanied by Ing. Ruben Ahumada, Chief of Public Relations Department, and heard explanations given by Director Jorge Galindo on bank investments, loans interest rates, etc. in the morning. In the afternoon, we explained to Arq. Quintanar, Arq. Navarro and Arq. Ponce Adame about the subway construction plan and conducted discussion on the matter.

4 (Sat.) Engaged in the making of our original plan for the subway system.

5 (Sun.) Holiday

6 (Mon.) Ing. Lozano Gallo visited our office to give us additional informational materials concerning the traffic situation in the city.

7 (Tue.) Inspected the sewerage system construction work in the morning. Heard explanations given by Arq. Ponce Adame about the nature of the soil in this district. Watched the work of blasting the rock located 6 meters underground.

8 (Wed.) Completed the drafting of our original plan and started translating it. Checked the translation line by line with the help of Arq. Navarro. Working till late at night every day since the beginning of this week.

9 (Thu.) Had the final consultation with Arq. Navarro and completed our intermediate report.

10 (Fri.) At noon, Lic Francisco Medina Asencio, Governor of Jalisco State, visited our office and heard our explanations about the contents of the repoort. He invited the investigation mission to the Guest House. At 8 p.m. we showed the movies at Guadalajara University and gave lectures on urban transportation.

11 (Sat.) Had a question and answer session with regard to the intermediate report. Had the final joint meeting to determine when and how the final report should be submitted. Commercial Attaché Okane from the Japanese Embassy was present. Invited to a reception given by the Mexican authorities concerned in recognition of our service.

12 (Sun.) Saw the sights of Guadalajara City through the good offers of Ing. Rubén Ahumada, Chief of Public Relations Department.

13 (Mon.) Left Guadalajara City in the afternoon and arrived in Mexico City in the evening of the day.

14 (Tue.) Made necessary arrangements for the future work at the Japanese Embassy.

15 (Wed.) Inspected the subway construction work now under way in Mexico City. Visited the Japanese Ambassador in Mexico to report to him on the results of our investigations made so far in Mexico. It was decided that our final report should be submitted to the Government of Jalisco State through the Japanese Embassy in Mexico within several months after the return to Japan of the investigation mission after its tour of the cities of the northeast of the U.S.A. to inspect the subways.

16 (Thu.) Left Mexico City. One group arrived in Boston and the other in Chicago.

17 (Fri.) The group that had arrived in Boston inspected the subway situation in the city and left the city in the evening and arrived in Philadelphia. The other group inspected the subway system in

	Chicago and left the city in the evening and arrived in New York.
18 (Sat.)	The former group inspected the subway system in Philadelphia, Leaving the city in the evening, it arrived in New York. The other group inspected the subway system in New York.
19 (Sun.)	The two groups joined together and inspected the subways in New York.
20 (Mon.)	Left New York and arrived in San Francisco. Inspected BART in the afternoon.
21 (Tue.)	Left San Francisco and arrived in Honolulu.
22 (Wed.)	Left Honolulu.
23 (Thu.)	Arrived at the Tokyo International Airport.

2. Introduction

It was necessary for the investigation mission to have a general knowledge of Mexico, the Federal District of Mexico, and Mexico City in compiling a report on the results of its investigation of the urban conditions and traffic situation in Guadalajara City. For this reason, what the mission had learned from several books and during its stay in Mexico will be given below.

1) United Mexican States (Fig. 1—1)

Location: The United Mexican States borders on the United States of America in the north and British Honduras and Guatemala in the south and faces the Pacific Ocean in the west and the Gulf of Mexico in the east. The country has a total area of 1,990,000 km^2, about five times the size of Japan that covers 370,000 km^2.

The populations has been increasing steadily as seen from the statistics below.

Year	Population
1950	26,000,000
1960	35,000,000
1965	41,000,000
1968	46,000,000

The populations in all states in 1950 and 1960 and their estimated populations for 1970 are given in Table 1-1.

Table 1-1. Gobierno Del Estado de Jalisco Departamento de Economia
Poblacion Estatal

Entidad	Superficil (km^2)	Años		
		1950	1960	1970
Aguas Calientes	5,589	188,075	243,363	314,887
Baja California N.	70,113	266,965	520,165	1,192,114
Baja California S.	73,667	60,864	81,594	109,377
Campeche	56,114	122,098	168,219	231,755
Coachuila	151,571	720,619	907,734	1,143,382
Colima	5,455	112,321	164,450	240,771
Chiapas	73,887	907,026	1,210,870	1,616,390
Chihuahua	247,087	846,414	1,226,793	1,778,114
Distrito Federal	1,499	3,050,442	4,870,876	7,777,328
Durango	119,648	629,874	760,836	919,014
Guanajuato	30,589	1,328,712	1,735,490	2,266,723
Guerrero	63,794	919,386	1,186,716	1,531,694
Hidalgo	20,987	850,394	994,598	1,163,182
Jalisco	80,137	1,746,777	2,443,261	3,984,959
Mexico	21,461	1,392,623	1,897,851	2,586,012
Michoacán	59,864	1,422,717	1,851,876	2,358,364
Morelos	4,941	272,842	386,254	546,834
Nayarit	27,621	290,124	389,929	524,065
Nuevo León	64,555	740,191	1,078,848	1,572,421
Oaxaca	95,364	1,421,313	1,727,266	2,098,974
Puebla	33,919	1,625,830	1,973,837	2,396,238
Queretaro	11,769	286,238	355,045	440,362

Quintana Roo	42,030	26,967	50,169	93,329
San Luis Potosi	62,848	856,066	1,048,297	1,283,640
Sinaloa	58,092	635,681	838,404	973,806
Sonora	184,934	510,607	783,378	1,201,859
Tabasco	24,661	362,716	496,340	679,142
Tamaulipas	79,829	718,167	1,024,182	1,460,586
Tlaxcala	3,914	284,551	346,699	422,418
Veracruz	72,815	2,040,231	2,727,899	3,647,201
Yucatan	43,379	516,899	614,049	729,429
Zacatecas	75,040	665,524	817,831	1,004,951
Total	1,967,173	25,779,254	34,933,129	48,289,321

Fuente Estimaciones del Departamento de Economia en base a los censos de 1950 y 1960.

Race: The majority of the Mexican people are of mixed Indian and Spanish blood and only a comparatively few are pure Indian and white such as Spanish and other Europeans naturalized in this country.

The whole country is divided into 32 administrative districts, namely, a Federal District, 29 States and two Territories.

Politics and economy: Mexico adopts a federal republican form of government and is one of the countries where the political situation is most stabilized in central and South Americas. The Mexicans are a patictic people. Mexico is rich in agricultural products and the living standard is higher than in other countries of this part of the world. The Government of Mexico is now endeavoring to transform the country from an agricultural nation to an agricaltural and industrial nation. Its monetary units are peso and centavos. One peso is equivalent exactly to 28 yen and 80 sen (¥28.80) but it would be convenient to regard one peso as worth about ¥30.

The Mexican society can be roughly divided into three classes--the upper, the middle and the lower classes. The upper class is composed of such people as bankers, business and industrial managers, senior engineers, and highranking goverment officials of the department chief class. Belonging to the middle class are ordinary public service employers, enginers, school teachers and other white collars, doctors and merchants. The lower class consists of day laborers, janitors, house servants and so forth. The people belonging to the upper class is greatly limited in number while the middle is explanding at a staedy rate.

The main agricultural products of this country are cotton, coffee, corn, sugar, fruits, meat and so forth. Rice is produced only to the extent that it is used as a subsidiary food. Mexico is rich in mineral resources and ranked high in the world in the production of silver, lead, mercury, copper and gold.

The educational standard is still not so high because about one-third of the people are said to be illiterate. The Government of Mexico now makes it one of its most important policies to raise the educational standard of the people. Mexican primary school education is now compulsory.

Transportation: Mexico has the nationwide networks of airline, highway and railroad services. The domestic airways are well developed and the major cities have a good airport so that the inter-city transport may be greatly sped up. There are good highways and well-developed long-and medium-range bus transport services. There are also many privately operated automobiles. The railroads give emphasis to the transportation of goods. Only a small number of passengers use the railroad service for long-distance travels.

Touriam: Blessed with the bright sunshine, beautiful scenery and the ruins of the fascinating ancient Mexican civilization, Mexico is an internationally famous tourist country and yearly attracts about 1,500,000 tourists from overseas, earning foreign currencies equivalent to ¥150,000 million. This figure is well over the total cost of construction of the proposed subway system in Guadalajara City, which will be discussed later in the present report.

2) Federal District of Mexico, Mexico City and Guadalajara City

Mexico City, the capital of the United Mexican States, is one of the 13 administrative sections of the Federal District of Mexico. Mexico City covers 138 km^2 and the Federal District of Mexico 1,500 km^2. The Federal District has a population that has been rapidly increasing in recent years as seen from the following population figures.

Year	Population
1960	4,870,000
1965	6,300,000
1966	7,200,000

About a half of the population of the Federal District is concentrated in Mexico City, which is on a planeau 2,240 meters above sea-level. Situated in lat. 19°N, Mexico City has a climate of continual spring. It is a city strongly international in appearance with modern buildings standing side by side along the streets.

In contrast to Mexico City, Guadalajara that is the capital of Jalisco State is a beautiful old city with a population of 1,400,000 and an area of 188 km^2, 1,567 meters above sea-level and in lat. 21°N, and about 600 kilo-meters northwest of Mexico City.

This City has been making a continuous growth with its steady economic development and yet the citizens are known for their traditional simplicity and friendliness. It is also reputed for its beautiful women. If Mexico City is compared to Tokyo, Guadalajara may be compared to Kyoto. We, the members of the investigation mission , stayed in Guadalajara for so short a period of time and were so busy during the period that we were not able to fully appreciated the beauty of this old city and to understand the goodwill of the people. However, as time went by after our retun to Japan, we have growing nostalgia for the days we passed in this beautiful city.

CHAPTER II. THE PRESENT STATE OF AFFAIRS IN JALISCO STATE AND GUADALAJARA CITY

1. *Topography*

Jalisco State is one of the 29 self-governing states and is situated nearly in the center of the Republic of Mexico (Long. 101°–105° West and Lat. 19°–23° North). It faces the Pacific Ocean in the west and borders on Mayarit State, Durango State, Zacatecas State and Aguas Calientes State in the north, Guanajuato State in the east and Michoacan State and Colima State in the south. The total area is 80,137 km². The northern part of the state has the southern end of the mountain range of the Sierramandore Occidental that extends from north to sough along the coast of the Pacific Ocean. Most of the state, except the mountaneous range, are highland plateaux about 1,500–3,000 meters above sea-level and the basins along the Santiago River and Lake Chapala. In the southern part of the state are the mountainous range including Mt. Colima and Paricutin Volcano, a young volcano that appeared in 1943. The temperature ranges from 6° C to 38° C with the annual average of 16° C, and the annual average rainfall is 850 mm.

Jalisco State is divided into 124 municipios (counties) that belong to five regions. Guadalajara is the capital of Jalisco State.

Region de la Costa is situated in the west of Jalisco State, bordering on the coast of the Pacific Ocean Puerto Vallarta is the principal city of this region that is composed of 11 municipios (counties).

Region Norte is the northern mountaineous area, which is divided into 10 municipios (counties). Its principal city is Colotlan.

Region de Los Altos covers the eastern highland plateau and has 23 counties. Lagos de Moreno and Tepatitlan are the most important cities in this region.

Region Sur is the southern plateaux and divided into 43 countries. CD Guzman is the principal city of this region.

Region Central is the central plateaux and has 37 counties. It has six major cities - Tlaquepaque, Zapopan, Tequila, Ameca, Ocotlan and La Barca.

Guadalajara, the administrative center of Jalisco State, is situated nearly in the center of Region Central in Long. 103° West and Lat. 21° North. It borders on Municipio Tlaquepaque on the east and Municipio Zapopan on the west. The city has a total area of 188 km², located along the upstream of the River Santiago on the plateauz 1,567 meters above sea-level. It sprawls in a basin with its downtown area on the bottom.

Guadalajara has developed from a community formed along a river and was established as a city in 1530. It is the political, economic and cultural center of Jalisco State with the history of 427 years.

The city is divided into four administrative sectors, namely, Libertad, Reforma, Hidalgo and Juarez by the streets of Eje Gigantes, Morelos, Calzada de Las Higuerillas and Calzada Independencia

2. Population and density of population

As shown in Table 2 - 1, the population of Jalisco State was about 2,440,000 in 1960 and increased to about 3,440,000 in 1967, showing an average annual increase of about 143,000 or 5 per cent a year during the past seven years. The average annual increase during the period between 1960 and 1965 (5-year period) was about 135,000. During the two-year period from 1965 to 1967, the population of this state increased by an annual average of about 160,000 a very rapid increase that has no perallel in any other state.

As seen from Table 2 - 2, the population of Gaudalajara was about 740,000 in 1960 and it increased to about 1,330,000 in 1967, an yearly increase of 8.8 per cent or about 84,000. The yearly average increase during the five years from 1960 to 1965 was about 76,000. The city's population also increased rapidly during the two years from 1965 to 1967, showing an annual average increase of 102,000. The population of Guadalajara has increased at a rate considerably greater than that of jalisco State.

As shown in Table 2 - 1, the population density of Jalisco State is rather low with 43 persons per square kilometer while Guadalajara City has a considerably high density of 7,100 per square kilometer.

The urbanized areas, as shown in Table 2 - 3, particularly the old urban areas, except for the high-class residential area in the downtown and western areas of the city, has a high density of population ranging from 15,000 to 30,000 per square kilometer. The densly populated section east of the city's center has 30,000 resident per square kilometer. There are some areas of extremely high population density of more than 30,000 persons per square kilometer that are scattered in the downtown area of the city. In the suburban districts, Tlaquepaque and Zapopan have relatively high population densities ranging from 15,000 to 30,000 per square kilometer, which are considerable higher than the population densities of the wards of Tokyo Metropolis that are given in Table 2 - 3.

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3. **Industries and employed workers**

Jalisco State has a mild climate throughout the year and abundant rainfall and fertile farmlands. It is the treasure house of agriculture, stock-breeding, forestry, hunting and fishing. The most important farm product is corn, which amounts to 2,500,000 tons or more than one-third of the total farm production of the nation. Sugar is another important agricultural product. Cattle-breeding is particularly important in the live-stock raising industry of this state, in which as many as 5,500,000 cattle are now being bred. As is shown in Table 2 - 4, which gives the numbers of people employed in various industries of this state, 45.5 per cent of the total working population are employed in agriculture, stock-breeding, forestry, hunting and fishing, 22.9 per cent in manufacturing industries, 12.5 per cent in commerce, one per cent in mining, 3.8 per cent in transportation, 14.2 per cent in service business, and 0.1 per cent in other trades. As is seen from Table 2 - 5, there is a steadily growing tendency for Jalisco State to shift gradually from pure agriculture to agriculture and industry.

In contrast, as many as 39 per cent of the working population of Guadalajara are employed in manufacturing industry as seen in Table 2 – 4. Chemical industry takes 30 per cent of the population employed in manufacturing industry, followed by service business that takes 24 per cent and commerce 22 per cent while agriculture, stock-breeding and other primary industries take only 7 per cent.

As seen in Table 2 – 4, 43 per cent of the total working population of Jalisco State are concentrated in Guadalajara City. The concentrations of the working population in the city are 73 per cent in manufacturing industry and about 74 per cent in service business, commerce and transport business. In other words, Guadalajara is the commercial and industrial center of Jalisco State with prolific agricultural hinterlands.

The main products of the city's manufacturing industries are oil, fats, soap, refined and unrefined sugar, alcohol, food (nutritious), shoes, electricity, metals, furniture, textiles, clothing, glass and so forth.

As will be seen from Table 2 – 7, the ratio of employed population to the total population of Jalisco State is 30 per cent and the corresponding percentage for Guadalajara is 33 per cent. Of the jobless people who take 67 per cent, 30 per cent are children younger than 12, students account for 6.5 per cent, those who are occupied with household duties 28.2 per cent, and others 2.3 per cent.

Fig. 2 – 4 shows the breakdown of the employed workers by age. As seen from this diagram, men and women of about 30 of age take the largest percentage and 50 per cent of them in an age bracket of 25 to 30 are employed. In this bracket 92 per cent of men and 41 per cent of women are employed.

The breakdown of all the employed people by type of profession shows that 2.2 per cent are the holders of managerial positions, 10.7 per cent for clerical workers, 19.9 per cent for salesmen, 7.1 per cent for farmers, 42.3 per cent for blue collars, and 17.8 per cent for those engaged in household duties and others.

Fig. 2-2 The seven territorial divisions with the largest population in D.F. and twenty-nine territorial divisions in United Mexican State

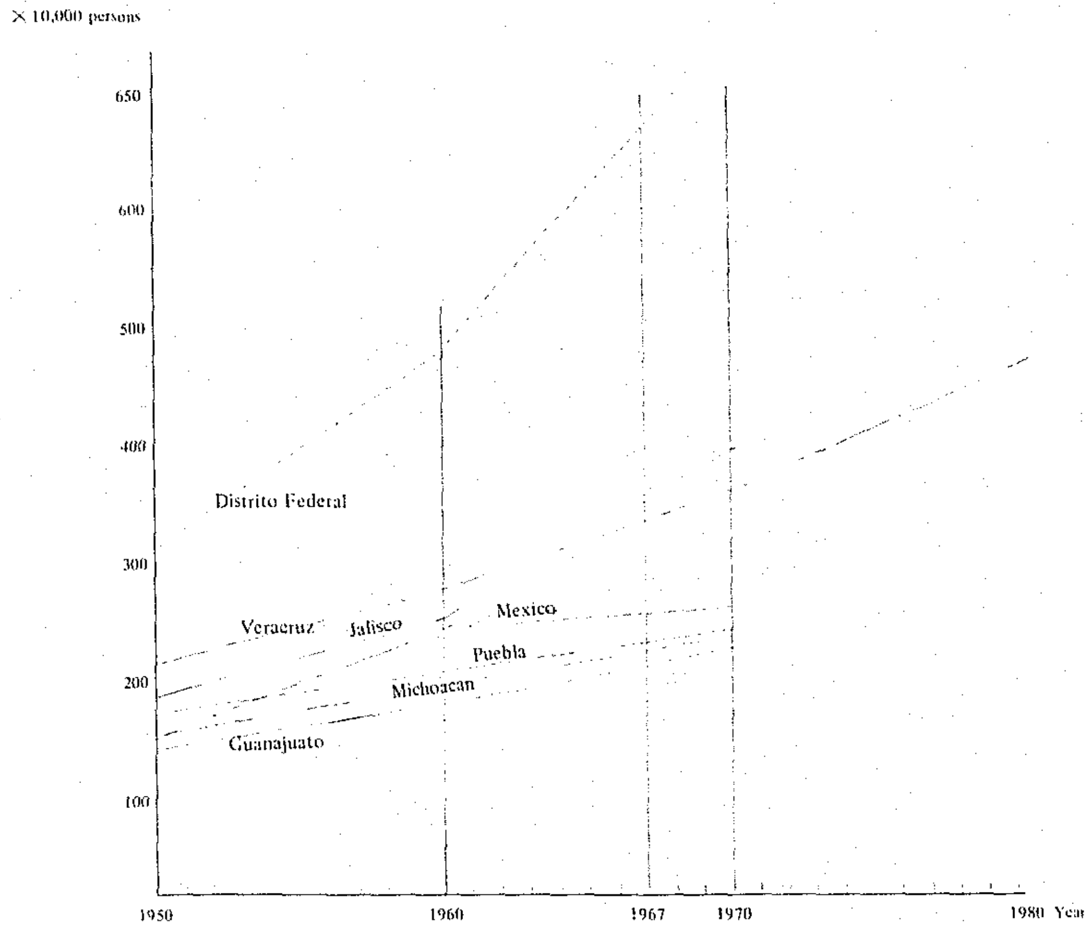
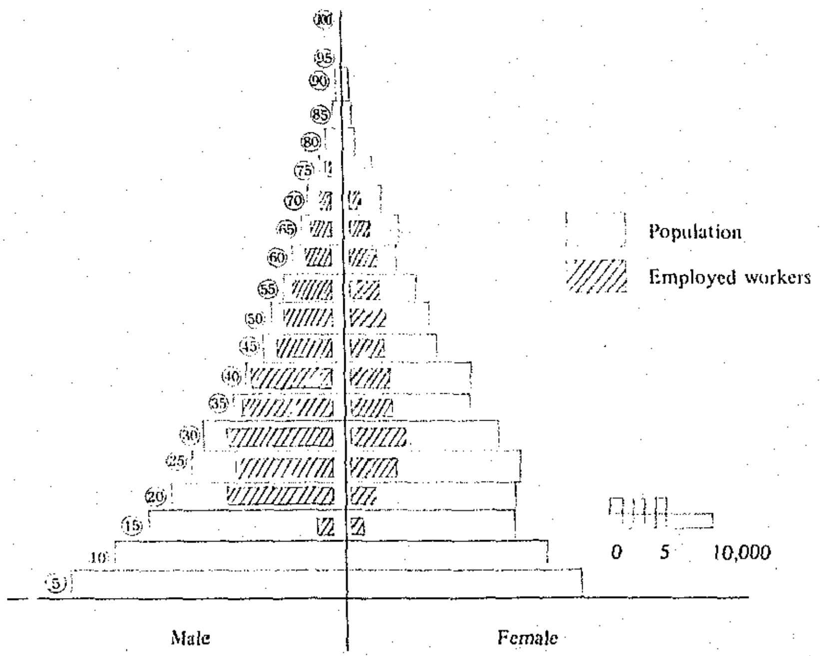


Fig. 2-4 Population and employed workers of Guadalajara City by sex and age



4. Urban structure

1) The history of urban development

The city of Guadalajara was founded in 1530. As shown in Table 2 - 5, in 1542 the city was composed of four communities – a community centering around the cathedral located in the center of the present city, two communities on both sides of the present Calzada Independencia, about one kilometer south of the center of the city, and one community located south of the Mezquitan cemetery, about 1.5 kilometers northwest of the center of the city. In 1750 the city incorporated two more communities in the south, showing a trend to expand to the south. In 1940 the city absorbed some more communities in the northwest, expanding to the east and west. In 1950 it further expanded to the west as far as Municipio Zapopan and a new community of San Martin was formed in the northeastern section. The city made a rapid expansion in 1960, especially in the southwest section and incorporated Zapopan in the northwest, Oblatos in the northeast and Tlaquepaque in the southeast. The city is still continuing to expand in all directions. The urban area now extends 15 kilometers from east to west and 10 kilometers from north to south.

2) Use districts (Fig. 2–6)

Guadalajara City is divided into 5 areas respectively designated as: (1) exclusive commercial area, (2) commercial area, (3) high-class residential area, (4) middle-class residential area, (5) ordinary residential area.

(1) Exclusive commercial area

This is a downtown area covering about 2 kilometers, centering around the Central Cathedral. Here is a government office and business center containing the State government office, the city office, business offices, theaters and courts, as well as a shopping center including department-stores, high-class speciality shops, high-class restaurants, movie houses and the like.

(2) Commercial areas

These are the areas extending along the peripheral areas of the downtown exclusive commercial area and the radial artery roads, the area sandwiched between the downtown area and the plaza in front of the railroad station, the area around the bus terminal, and the area around the crossing of the Zona Commercial Lafayette and the Avenida Juarez. This area is the mixing area of business, commercial and residential area.

(3) High-class residential area

This is the area which extends centering around Ave. Vallarta in the western part of the downtown area and stretches along Ave. Lopez Mateos, an arterial street running from north to south, to Jardines del County in the north and to Ciudad del Sol.

(4) Middle-class residential areas

The middle-class residential areas are in the peripheral area of the downtown area in the center of the city, around Algodonal in the northwestern section, around Fraccto Independencia in the northern section, and along Avenida Javier Mina, an arterial street running from east to west, stretching to San Andres.

(5) Ordinary residential areas

This type of residential areas are found around La Federacha in the north, San Andres in the east, San Pedro Tlaquepaque in the southeast, Zona Industrial in the south, and along Calzada Manuel Avila Camacho and Avedel Trabajo in the northwest.

Residential building lot	
High-class residence:	Usually 1,000 m^2 or so
Middle-class residence:	Usually 200 m^2 (10m x 20m)
Low-class residence:	Usually 105 m^2 (7m x 15m)

The average family has about 7 members.

No specific area has been reserved specially for industrial purpose but now the Zona Industrial is being prepared for this purpose in the southern part of the city. This city has many family workshops, particularly shoe-makers, scattered in the downtown area and in the eastern residential areas.

3) Urban Facilities (Fig. 2 – 7)

The following is a brief description of the urban facilities in various sectors of this city.

(1) Sector Libertad

Sector Libertad is in the northeastern part of the city. To the southwest of this section are a large market place, the Mariachi Plaza, the Cabañas Orphanage that houses the famous fresco "Man of Fire" that is regarded as one of the greatest masterpieces of the great Mexican painter Orozco, and a bullring. There are a prison in the south, the Centro Medico social insurance hospital in the west, a bullring in the northwest and the Guadalajara cemetery in the north.

The densely populated city areas of this district have many shoemakers' shops scattered all over and many dwelling houses. A new residential area is extending rapidly toward Oblates in the northeast.

(2) Sector Reforma

This section is situated in the southeastern part of Guadalajara. In the downtown area to the northwest of this district is a shopping center with many movie theatres. A railroad line of Nacionales de Mexico runs through the southern part of this sector and along the railroad there is a big public park Gonzalez Gallo. In the west are a railroad station Estacion de pasajeros and a big public park Agu Azul adjoining the station plaza, and a bus terminal the Central Bus Terminal. A big public Park San Rafael is the eastern part of this sector and in the center are Ciudad Universitaria, Pensiones Federales and Cuartel Colorado.

This sector as Libertad has a high degree of population density in its urban areas and its residential areas are gradually expanding into the suburbs, absorbing already Tlaquepaque in the southeast.

(3) Sector Juarez

Sector Juarez is situated in the southwest part of the city. This section is divided into northern and southern parts by the railroad line of Nacionales de Mexico running through the middle of the city from east to west and there is the yard of Ferrocarril del Pacifico on the northern side. The downtown area in the northeast contains the government office of Jalisco State, the general headquarters of the university and other buildings centering around the Central Park. Along Av. Juarez, an arterial road running from east to west are department-stores and shopping and business centers. Office buildings and hotels stand side by side along 16 de Septiembre, an arterial road running from the railroad station of Estacion de Pasajeros to the north. There are many auto-dealers' shops and business offices along Av. Washington and Av. Niños Heroes, arterial roads running in front of the railroad station from east to west. In the west is a high-class residential area sprawling along Av. Juarez, a street running from east to west, Commercial Lafayette, a street running from north to south, and Av. Union. In the peripheral areas are emerging high-class and middle-class residential areas such as Cividad Granja, Prados Vallarta, Tepac Casino, Verda Valle and Las Fuentes.

In the south Zona Industrial (industrial zone) is now under construction and new residential houses are being built at Lomas de Polanco.

(4) Sector Hidalgo

Sector Hidalgo is a section situated in the northwestern aprt of the city. In the downtown area in the southeast are the Central Cathedral, the Liberation Park, the city office, court, museum, greatman temple. Degoyard theatre and other important structures and also a high-class shopping street with department stores around them for the center. A big park of Morelos is in the eastern outskirt of the downtown area and the Revolucion Park in the western outskirt. In the south a shopping street has developed along Morelos, a road running from east to west. In the western old downtown area is a high-class residential area on both sides of Americas. There is a growing high-class residential area in the area of Avila Camacho extending to Zapopan in the northwest. In the center of this sector are the Mezquitan cemetery, the Park and the Alcalde Park and the Hospital Civil and a densely populated middle-class residential area. In the northeastern part of this sector is a soccer field.

The northwestern outskirt of this sector has an undulating topography but there is steadily growing tendency of urbanization, already absorbing Zapopan. This trend is further progressing to include Zoquipan and Atemajac in the east into the urban areas of Guadalajara. A high-class residential area is now being developed on the heights of Lomas Del Valle in the western outskirt of this sector. A university is also under construction.

4) Road and streets (Fig. 2-8-1, Fig. 2-8-2)

Guadalajara is easily accessible by the five main arterial streets radiating from its center. The streets are Carretera a Chapala radiating from the southeast, a Mexico via Piedad and a Tonala to the east, Carrera a Saltillo from the north, a Nogales Tequila from the west and Av Lopez Mateos Sur from the southwest.

(1) Carretera a Chapala is State Road No.35. Linking the city areas and the Guadalajara Airport, this road further extends to a villa residential area along the shores of Lake Chapala in suburb about 40 kilometers away from the downtown area of Guadalajara. It joins with National Raod No. 15 on the western side of the lake.

(2) A Maxico via La Piedad is National Road No. 80. It is an arterial road that links Guadalajara and Mexico City via Quéretaro and is joined by many other roads running across the eastern part of Jalisco State.

(3) Carrera a Saltillo is State Road No. 11, a main arterial road connecting the cities in the northern part of Mexico such as Zacatecas and Monterrey.

(4) A Nogales Tequila is National Raod No. 15, a main arterial road linking the major cities along the northern Pacific coast such as Mazatlan and Mexicali and is joined by many other roads running across the northern and western parts of Jalisco State.

(5) Av. Lopez Mateos Sur is also National Road No. 15. This is a main arterial road that goes around Lake

Table 2-1 Population and population density of Jalisco State

80,137.00 km²	Population	Population density (per square kilometer)
1950	1,746,777	22
1955	2,065,857	26
1960	2,443,261	35
1965	3,120,307	38
1967	3,441,029	43

Table 2-2 Population and population density of Guadalajara City

187.91 km²	Population	Population density (per square kilometers)
1950	380,266	2,000
1955	530,576	2,800
1960	740,394	3,800
1965	1,122,875	5,900
1967	1,326,413	7,100

Table 2-3 Population and population density of Tokyo Metropolis

	Area	Population	Population density (per square kilometer)
Tokyo Metropolis	2,026.89	11,208,088	5,524
Central districts divided into wards	569.51	8,961,545	15,678
(Large ward)			
Setagaya	58.81	769,275	13,081
Ota	41.70	750,778	18,004
Suginami	33.54	545,902	16,276
(Medium-size ward)			
Nakano	15.73	380,344	24,180
Katsushika	33.90	464,954	13,703
Edogawa	45.18	436,467	9,661
(Small-size ward)			
Minato	19.01	234,685	12,287
Chuo	9.65	119,219	11,886
Chiyoda	11.52	88,484	7,681

(Note) Estimated statistics as of February 1, 1968

Table 2-4 *Percentage distributions of employed population by sectors in Jalisco State and Guadalajara City*

1967

	Total	Agriculture Live-stock Forestry Hunting Fishing	Manufacturing Mining	Processing industry							
				Chemical	Construction	Electricity Gas	Total	Commerce	Transport	Service	Others
Jalisco State	988,426	449,454	10,081	170,326	52,562	3,108	225,996	124,001	38,025	139,696	1,173
	100%	45.5	1.0	17.3	5.3	0.3	22.9	12.5	3.8	14.2	0.1
Guadalajara City	421,532	29,610	4,650	127,821	34,498	2,369	164,688	91,626	27,902	102,196	860
	100%	7.0	1.1	30.3	8.2	0.6	39.1	21.8	6.6	24.2	0.2
Percentage ratio of Guadalajara to Jalisco State	43%	7	46	75	66	76	73	74	73	73	73

Table 2-5 Industrywise Breakdown of Employed Population of Jalisco State

1950–1967

Year	Total	Agriculture Live-stock Forestry Hunting Fishing	Manufacturing Mining	Processing industry							
				Chemical	Construction	Electricity Gas	Total	Commerce	Transport	Service	Others
1950	555,713	324,660	1,652	70,446	17,841	1,775	90,062	48,218	13,366	50,279	23,750
1955	641,307	357,252	2,812	91,333	24,515	2,093	117,941	63,659	18,178	67,907	9,804
1960	757,001	393,116	4,787	118,413	33,686	2,468	154,567	84,045	24,723	91,716	4,047
1965	913,574	432,580	8,149	153,522	46,287	2,910	202,719	110,959	33,624	123,872	1,671
1967	988,426	449,454	10,081	170,326	52,562	3,108	225,996	124,001	38,025	139,696	1,173

Table 2-6 Industrywise Breakdown of Population of Guadalajara City

1950–1967

Year	Total	Agriculture Live-stock Forestry Hunting Fishing	Manufacturing Mining	Processing industry				Commerce	Transport	Service	Others
				Chemical	Construction	Electricity Gas	Total				
1950	130,651	8,863	409	37,512	9,917	937	48,366	23,642	6,943	28,374	24,054
1960	250,395	18,019	1,709	77,155	20,647	1,647	99,419	52,452	15,736	60,295	2,765
1965	362,666	25,692	3,493	110,653	29,792	2,124	142,569	78,127	23,690	87,894	1,201
1967	421,532	29,610	4,650	127,821	34,498	2,369	164,688	91,626	27,902	102,196	860

Table 2-7 Employed Populations in Jalisco State and Guadalajara City

Year	Jalisco State			Guadalajara City		
	Total population	Employed population	%	Total population	Employed population	%
1950	1,746,777	555,713	32	380,226	130,651	34
1955	2,065,857	641,307	31	530,576	181,469	34
1960	2,443,261	757,001	31	740,394	250,395	34
1965	3,120,307	913,574	29	1,122,875	362,666	32
1967	3,441,029	988,426	29	1,326,413	421,532	32

The working and school hours

Working Hours

Category	Working hours	Recess	Number of trips
Factory	8 a.m. –– 5 p.m.	1 p.m. – 2 p.m.	2
Shop	9 – 7	2 – 4	4
Bank	9.30 – 1.30	–	4
Government office	8 – 3	–	2
Business office	9 – 7	2 – 4	4
Theater	4 – 11	–	–
Cinema house	4 p.m. – 11 10 – 1 for Sunday 4 – 11		Once a week Twice a week for car owners

School Hours

Primary school	8 a.m. to	2 p.m. or	3 p.m. to	7 p.m.	(In case of two-shift system Morning – boys Afternoon – girls)
Middle school	8 a.m. to	2 p.m. or	3 p.m. to	7 p.m.	(")
High school	8 a.m. to	2 p.m. or	3 p.m. to	7 p.m.	(")
University	7 a.m. to	9 p.m. or	7 p.m. to	10 p.m.	(")

(Note) Only the state-operated schools have afternoon classes.

Sports

Sports	Soccer		Wrestling	Boxing
Hours Days	12 a.m. – 2 p.m. Sunday Wedneseday	4 p.m. – 6 p.m. Once a week	– Friday	– Thurseday

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Chapala and through the city of Morela to reach Mexico City. It is joined by many roads running the south and southeastern parts of Jalisco State.

In an attempt to lessen the traffic congestion, Guadalajara, accepting these five main arterial roads, is now planning to build by-passes for the four arterial roads of a Nogales Tequila and Av. Lopez Mateos Sur coming from the west and a Mexico via Lapiedad and Carretera a Chapala coming from the southeast so that they may be separated from the traffic within the city by elevated roads.

The streets of the city that are linked to the radial arterial roads are the four main streets such as Av. Javier Mina and Av. Juarez running from east to west and nine main streets such as Calzada Independencia Sur running from north to south. The city areas of Guadalajara is crisscrossed by parallel streets running from east to west and from north to south. In the suburban areas the streets radiate from the arterial roads. Construction of a loop road is being planned and partially enforced around the downtown area of the city. When completed the loop road will circle the downtown area about 4.5 kilometers to the east and west and about 2.5 kilometers to the north and south from the downtown area. An outer loop road is also being planned and partially completed to run through the suburban areas of the city (about 11.5 kilometers to the east and west and about 6 kilometers to the north and about 10 kilometers to the south from the downtown area.)

5) Universities

Guadalajara City has three universities – one state-operated and two private universities. The state university has many departments that are located scattered all over the urban area and is the composite university and its general headquarters in the downtown area. The students come from all parts of Jalisco State and the Pacific coastal areas of this country and they total about 15,000 at the present time.

One of the two private universities has a long history and has many departments scattered over the city as the state university. It is now carrying on a five-year plan for concentrating all the departments on the Lomas del Valle heights about 8 kilometers west of the city. This university has about 10,000 students coming from the State of Jalisco and Central and South American countries.

The other private university is still young, only 10 years old, and is situated in a high-class residential area in the southwestern part of the city, Verde Valle.

6) Railroads

The city's railroad station Estacion de Pasajeros located about 2 kilometers south of the downtown area is linked with the railroad line of Ferrocarril del Pacifico coming from the west and Ferrocarriles Nacionales de Mexico coming from the southeast. Ferrocarril del Pacifico runs trains once a day from Mexicali and Nogales situated on the Pacific coast near the U.S. border and once on every Tuesday, Wednesday and Friday from Etzatlan situated about 60 kilometers west of Guadalajara. Ferrocarriles Nacionales de Mexico runs trains twice a day from Mexico City, capital of the Republic of Mexico (one of the two trains has first-and second-class cars) and also from Manzanillo on the pacific coast in the southern part of Jalisco State (One of the trains is operated once on every Tuesday, Thursday and Saturday).

These railroads are inter-city railroads between Guadalajara and other cities and greater emphasis is given on goods transportation.

7) Parking Lots

No overall plan has been made as yet for the automobile parking lots in the whole city of Guadalajara. The Government of Jalisco State is scheduled to set about making the plan this year.

In order to cope with the steady increase in the number of automobiles operating in the downtown area of Guadalajara, multi-stories ferro-concrete parking places are now being built. By 1967 there will be four of such modern parking lots with a combined capacity of accommodating 1,000 cars and by 1968 the number is expected to increase to 12 with a total capacity of 2,000 cars.

The city is planning to install more than 2,500 parking meters along both sides of the wide streets near the downtown area to collect fees from the users of the parking spaces. Thus raised money is devoted to the improvement of the roads and parking facilities of the city. As many as 600 parking meters were already set up and fees collected by 1967.

The user of the sheltered parking place is charged 2.5 peso per hour for the first one hour and 0.5 to 1.0 peso more per hour thereafter. The motorist can use the open parking lot with a prking meter by paying 0.8 peso per hour.

5. Transport facilities

Passenger traffic in and around Guadalajara is now carried by buses, taxis and privately-owned cars. About two-thirds of the traffic is carried by buses.

1) Buses

At present, 8 privately-owned bus companies are operating bus services in the city. They owned 1,416 buses in total and were operating 115 main bus service routes as of 1967.

Buses are the means of transport most popularly used by the ordinary citizens because the bus fare is comparatively cheap, the buses are operated frequently, the intervals between bus stops are short, and a passenger can stop a bus and get on anywhere only by raising his hand in the civic center. About 1,300,000 bus tickets were sold a day on the average as of November, 1968.

Owing to the restrictions on the use of roads and the transport requirements, each bus line is further ramified into several routes, forming a very complicated network of bus lines in this city and the marking on the bus showing its route and signs for bus stops are rather difficult to understand. So, the users of the bus service except those who are well informed of the bus traffic should ask the driver or be very careful when they take a bus in this city.

Most of the buses operating in this city are of the bonnet type and have only one door beside the driver's seat. Since the "one-man" system ins adopted, the buses are running with the door open most of the time in the midtown section.

Since no bus company inthis city sells the commutation tickets, you must have small change when you take a bus. Table 2 – 8 shows the numbers of buses owned by the city's bus companies and the bus service route operated by them. Fig. 2 – 9 shows the bus routes.

Table 2-8 The number of buses owned by the city's bus companies (1967)

Name of company	Number of buses	Number of bus routs
Guadalajara–Tlaquepaque	121	9
Union de Perimisionarios	464	33
Mexicaltzingo–Mezquitan	73	4
Norte–Sur	93	4
Oblatos Colonias	138	11
Circunvalacion	112	8
Analco Moderna	249	31
Centro Colonias	166	15
Total	1,416	115

Near the center of the city is a large bus terminal for the mediumrange buses running to and from the suburban towns and villages and longrange buses running to and from Mexico City and other distant cities. These buses are popularly used by the people because the bus fares are equal to the railroad rates, the buses are operated very frequently (at intervals of one hours for the suburban districts) and they run through the most densely populated areas.

2) Taxicabs

The city has 34 taxi companies operating about 1,600 taxicabs. These companies have 106 business offices scattered all over the city (as shown in Fig. 2 – 10).

The business office is required to keep always a fixed number of taxicabs ready for use by the passengers. When a car is sent out at the request of a fare, a cab standing by in the garage or at the driver's home will be called in to fill the vacancy. This being the case, there are not so many taxicabs cruising along the streets. Instead, there are many telephones on the streets in the midtown district which are exclusively for calling a taxi. A taxi can be hired easily by making a telephone call, using such street telephones and any telephones in hotels, shops and the like.

The taxi fare is uniformly fixed at 5 pesos (¥150) within the boundaries of the city and it is increased to 7 to 10 pesos (¥210 – ¥300) if it goes out into the suburbs (for from 6 or 7 kilometers to about 10 kilometers). The taxi fares are considerably high, compared with the bus service. However, there are so many taxicabs in this city that you will have not much difficulty in hiring a taxi even during the busy tourist season. The Government of Jalisco State is now studying a plan for adopting a meter system for the taxicabs so that they may be used more easily by ordinary citizens.

3) Private passenger-cars

There were 47,100 privately-owned cars in this city as of the end of 1968. This means that there was one car for every 32 persons in the city.

Mexico does not import foreign-made passenger-cars and instead manufactures cars in the country by introducing foreign capital. For this reason, the passenger-car is considerably high in price, compared with other goods, and consequently the owners of cars are limited to the people belonging to the middle-upper-class. There are not a few upper-class families that own more than one car. So, there is a considerable number of privately-owned cars used for going to and from work or school or going to the midtown section for shopping. It is commonplace to see the privately-owned cars parked side by side along both sides of the city's wide streets except the "no-parking" areas (Av. Juarez and Calzada Independencia) during the daytime.

4) Trends in number of cars classified by transport means

Table 2 – 9 shows the recent trends in number of licensed vehicles of various types of transport menas in Guadalajara. As seen from this table, the number of privately-owned cars has increased enormously while trucks did not and privately-owned buses decreased noticeably. Ordinary commercially operated buses have increased steadily.

Apart from the four-wheeled vehicles, bicycles and motor-cycles are popularly used by the general people. In recent years, motor-cycles have been increasing while bicycles are decreasing gradually.

Table 2-9 The up-and-down movements of the numbers of vehicles of various types of transport means in recent years

Year	Passenger-car		Truck		Bus		Motor-cycle	Bicycle
	Private	Taxi	Private	Commercial	Private	Commercial	Private	Private
1965	31,370	1,216	10,911	431	131	1,157	3,938	48,500
1967	40,692	1,342	13,191	491	164	1,341	6,021	44,500
1968	47,100	1,600	12,800	440	52	1,490	7,180	27,000

5) The present state of road traffic

Guadalajara City has well-developed street owing to the city planning effected in the past. However, since these street were built in the days when no one expected such an enormous increase in the automobile traffic as seen today, the city's street except the main street are not very wide, most of them have only two lanes.

The streets of the city areas are regularly arranged like a checker-board with the parallel street running from east to west and from north to south at intervals of about 100 meters.

The one-way traffic is imposed on all the street except the main thoroughfares. All crossings have "preference signs" so that the streams of traffic in a particular direction may have preference to go first.

Traffic signals are installed in all crossings of main street of this city.

The traffic in and around the city greatly increases and considerably congested four times a day, from 8.30 a.m. to 9:30 a.m., from 2 p.m. to 2:30 p.m., from 3:30 p.m. to 4 p.m. and from 7 p.m. to 9 p.m.The highest peak is reached during the period from 2 p.m. to 2:30 p.m. This is because there is the rush of pedestrians and cars going home to take a noon rest after the morning's work and there is enormous traffic congestion in the roads of the midtown section.

Table 2 – 10 shows the numbers of pedestrians and cars and bus routes in operation in the street of the midtown section during the one hour of the most congested traffic.

Table 2-10 The volume of traffic in the main street of the city

Direction	Name of street	Width	Volume of traffic during rush hours		Number of bus routes in operation
			Passenger-car	Pedestrian	
South-north	Calzada Independencia	14 x 2	Over 3,000 per hour	1,200 per hours	Over 20 routs
	Av. Alcalde	19	2,000 – 2,500	800 – 1,200	
East-west	Av. Juarez	15	1,500 – 2,000	Over 1,200	10 – 15 routs
	Hidalgo	15	800 – 1,000	800 – 1,200	"

(Note) The passenger-car figures are derived from the statistics of October of 1967.

Calzada Independencia carries the greatest volume of traffic, more than 3,000 cars and more than 1,200 pedestrians an hour. There are overhead pedestrian bridges at three places in the crossing of this street and Av. Juarez.

The streets behind the main thoroughfares have very frequent bus services. For instance, as many as 26 buses are operated during the period of 10 minutes during the rush hours in Pedro Moreno (eastbound), a road running of the north of Av. Juarez, and 38 buses in 10 minutes in Eje-Morelos running of the north of Pedro Moreno.

The buses stop at every crossing for the passengers to get on and off and this greatly reduces the average operating speed and further increases the congestion of road traffic.

6) The numbers of user of mass transport means

According to the statistics provided by the Government of Jalisco State, the volume of traffic carried by buses a day in the main roads of Guadalajara City is as shown in Fig. 2 – 11. As seen in this figure, the bas passenger traffic is greatest in the street between the midtown section and in Zapopan in the northwest part of the city, numbering 228,000, followed by the street linking the midtown section with the east, southern and southeastern sections with the passenger figures of 156,000, 156,000, and 150,000, respectively.

The bas passenger traffic between the midtown section and suburban areas total 1,125,000 a day, which accounts for 80 per cent of the daily total of bus passengers of 1,300,000.

7) Traffic Accidents

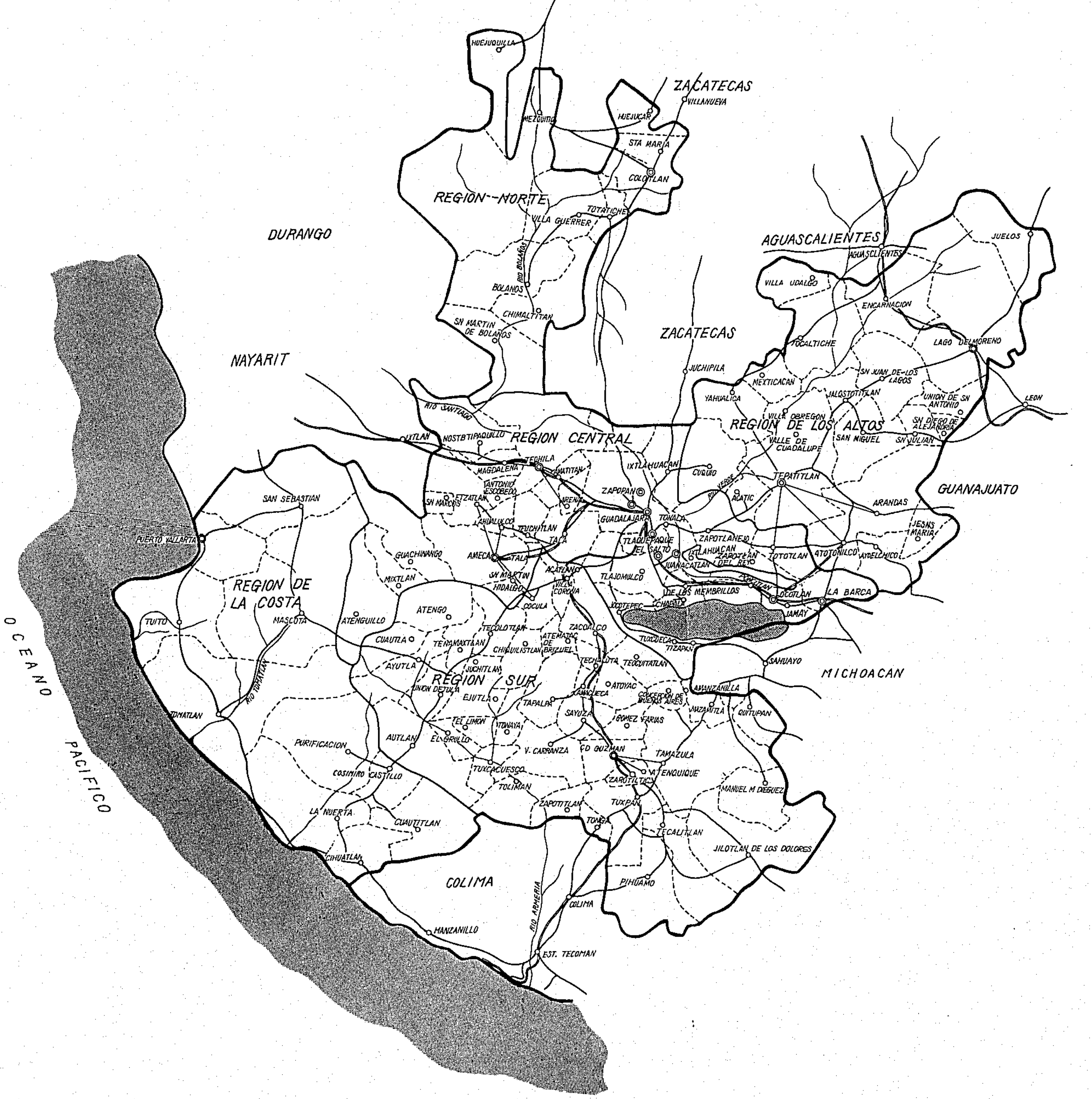
Traffic policemen are stationed in the main crossings of the city to regulate the traffic during the rush hours. This city seems to have a comparatively low rate of traffic accidents because the behavior of the automobile operators is generally good. In actuality, however, there are a considerable number of accidents. These accidents seem to be caused by congested road traffic, inadequate maintenance of vehicles, inexperience of the drivers. A total of 790 accidents occurred in and around the midtown section during 17 months from January 1966 to May 1967. The following crossings had the most frequent accidents in the midtown section.

Crossing	Number of accidents
Crossing of Calzada Independencia and Av. Juarez	111
Crossing of Calzada Independencia and Hidalgo	64
Crossing of Calzada Independencia and Eje-Morelos	61
Crossing of Calzada Independencia and Lcotilla	58
Crossing of Calzada Independencia and Pedro Moreno	40

31

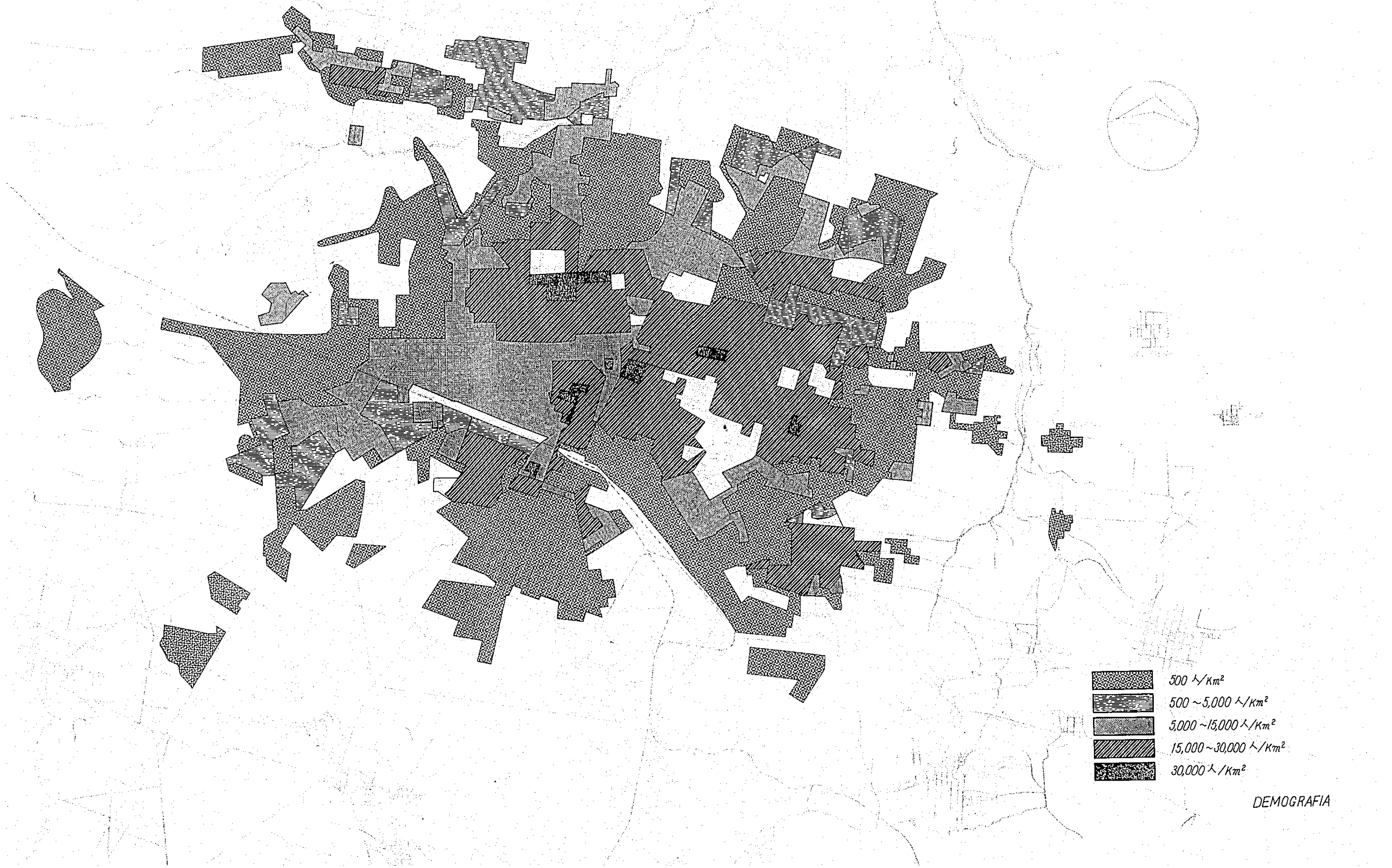
COMPLETE MAP OF JALISCO STATE

Fig 2—1



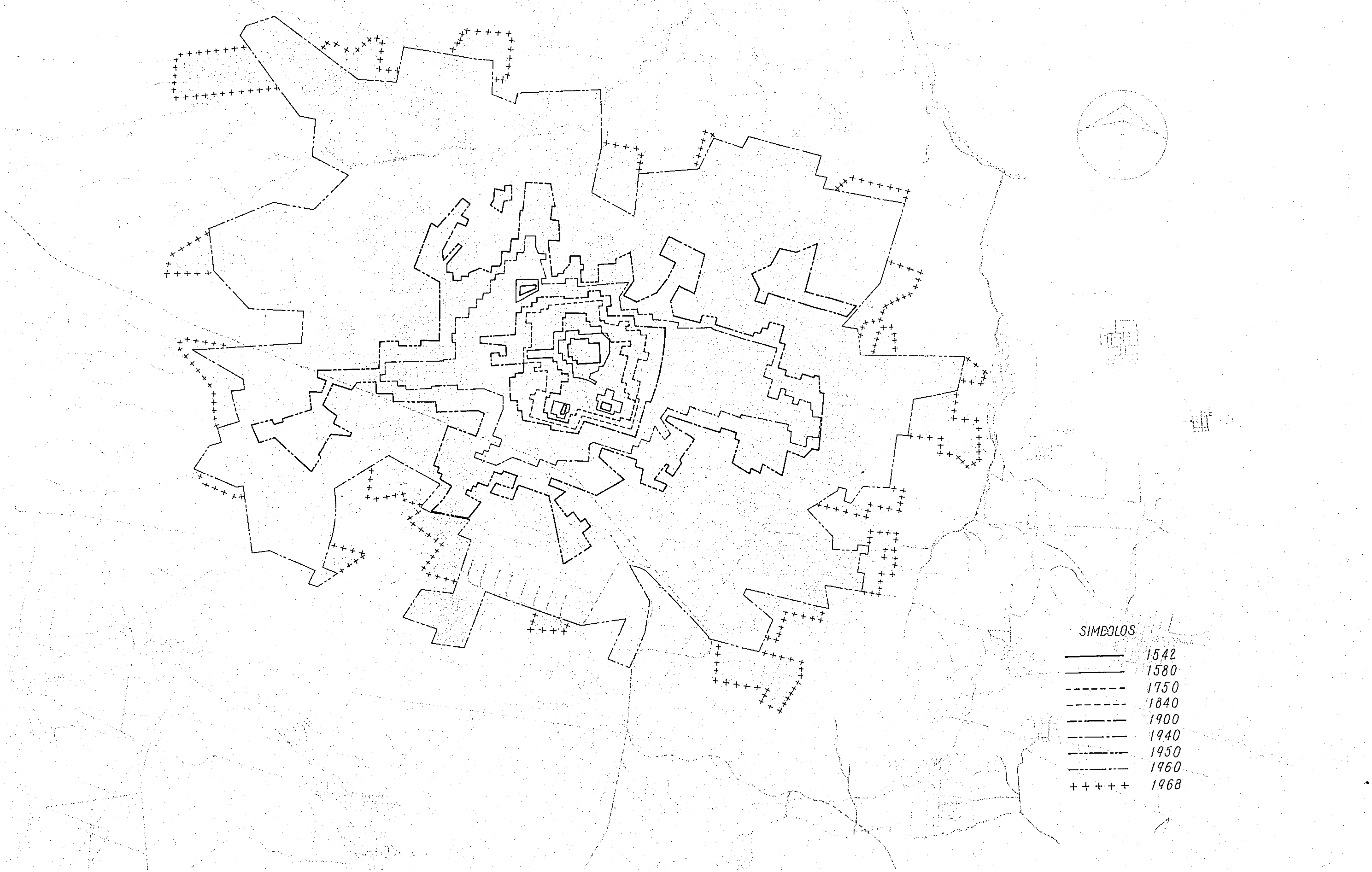
POPULATION DENSITY OF GUADALAJARA CITY

Fig 2—3



DEVELOPMENT OF GUADALAJARA CITY

Fig 2—5

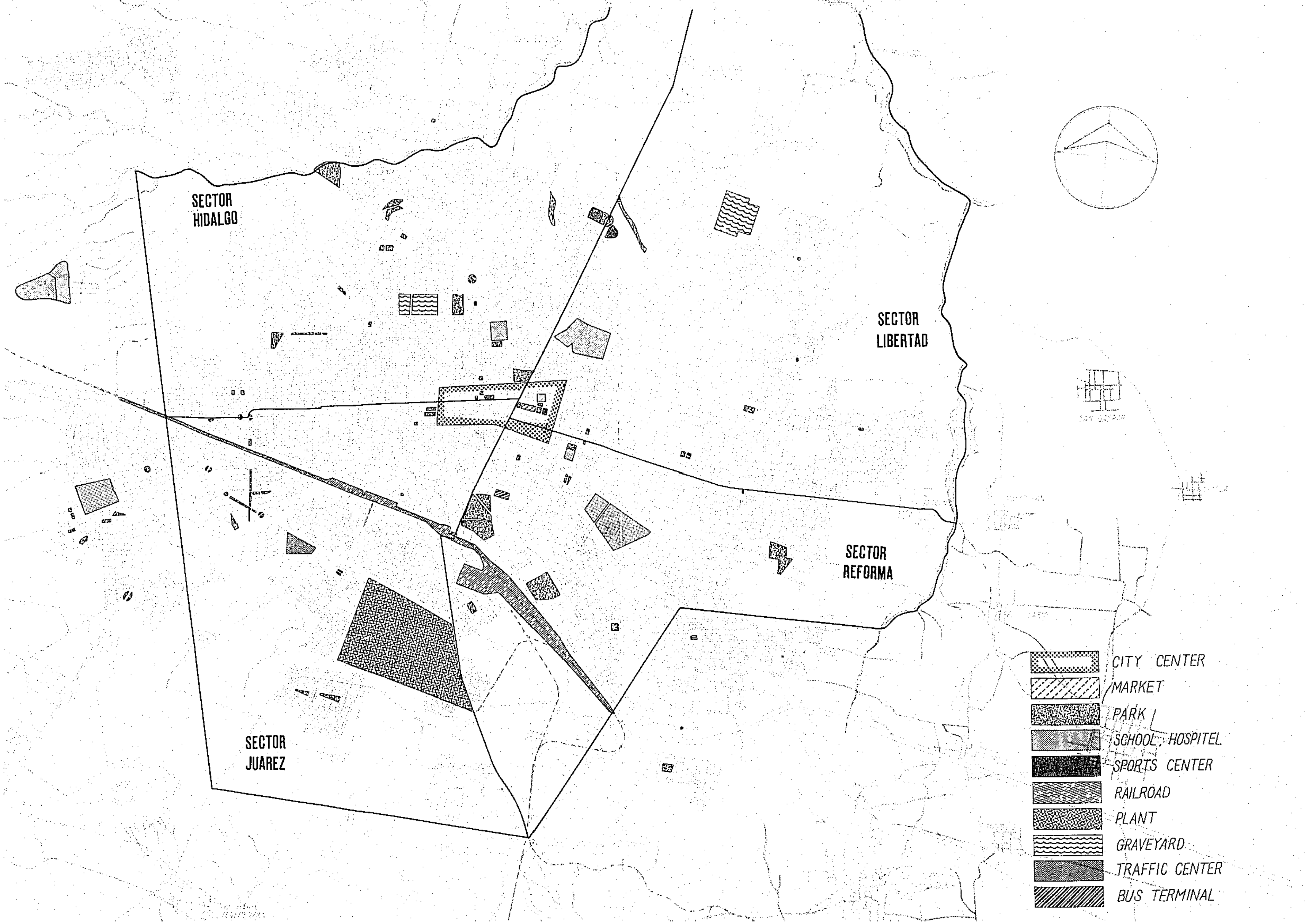


ZONES CLASSIFIED BY USE IN GUADALAJARA CITY

Fig 2—6

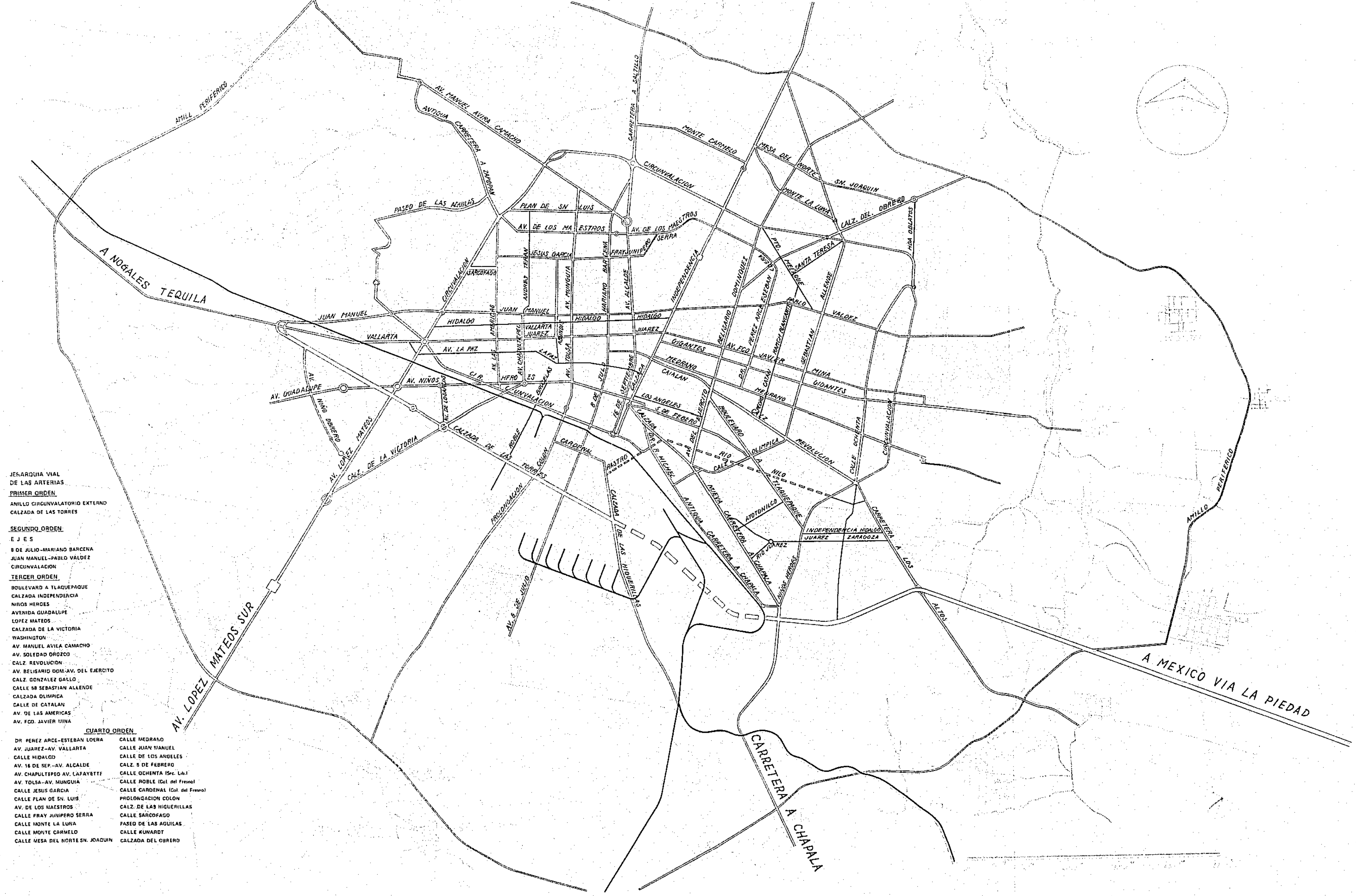
URBAN FACILITIES IN GUADALAJARA CITY

Fig 2—7

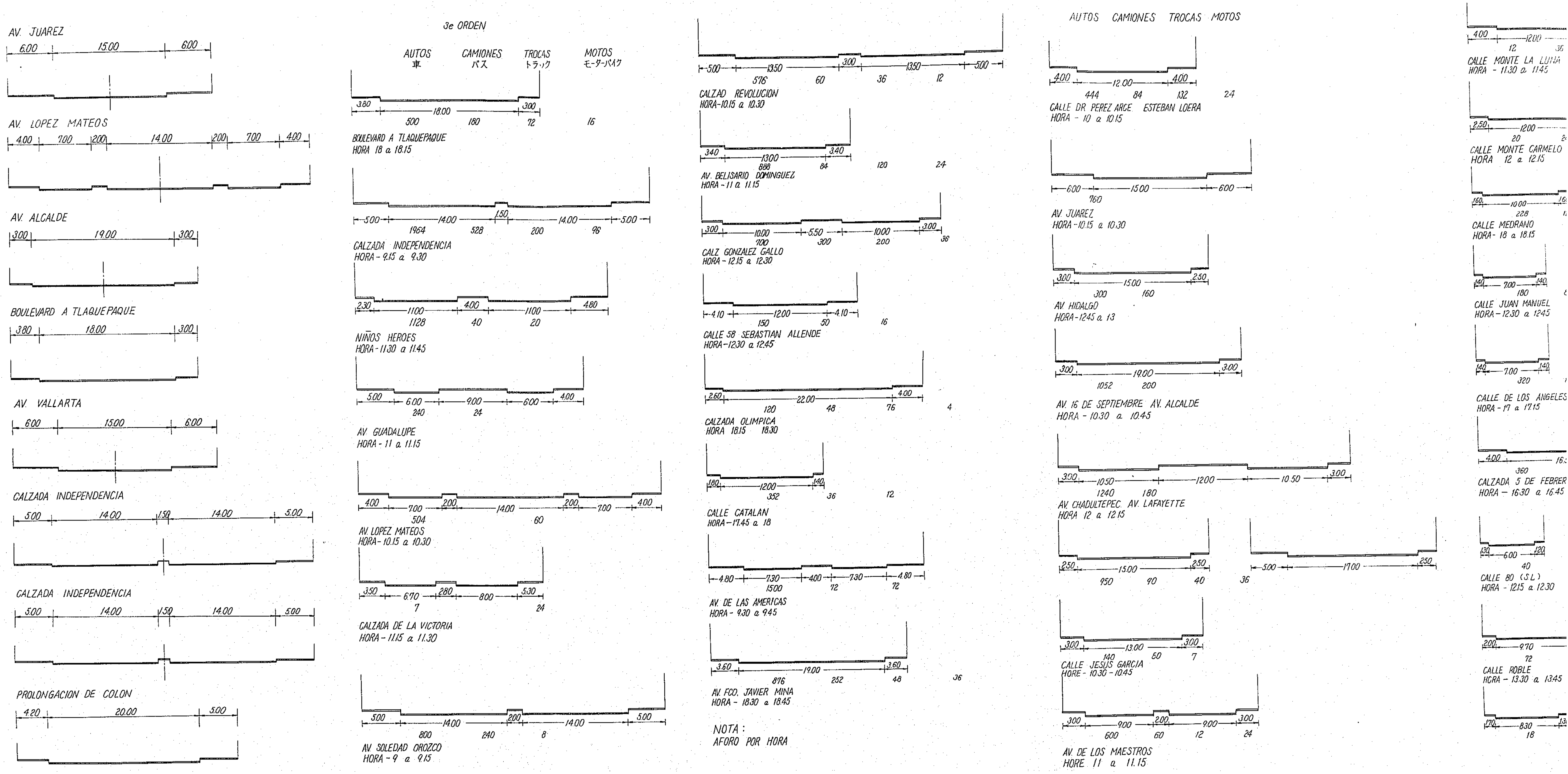


MAIN ROADS, STREETS NETWORK AND CROSS SECTIONS OF STREETS OF GUADALAJARA CITY

Fig 2—8 —1

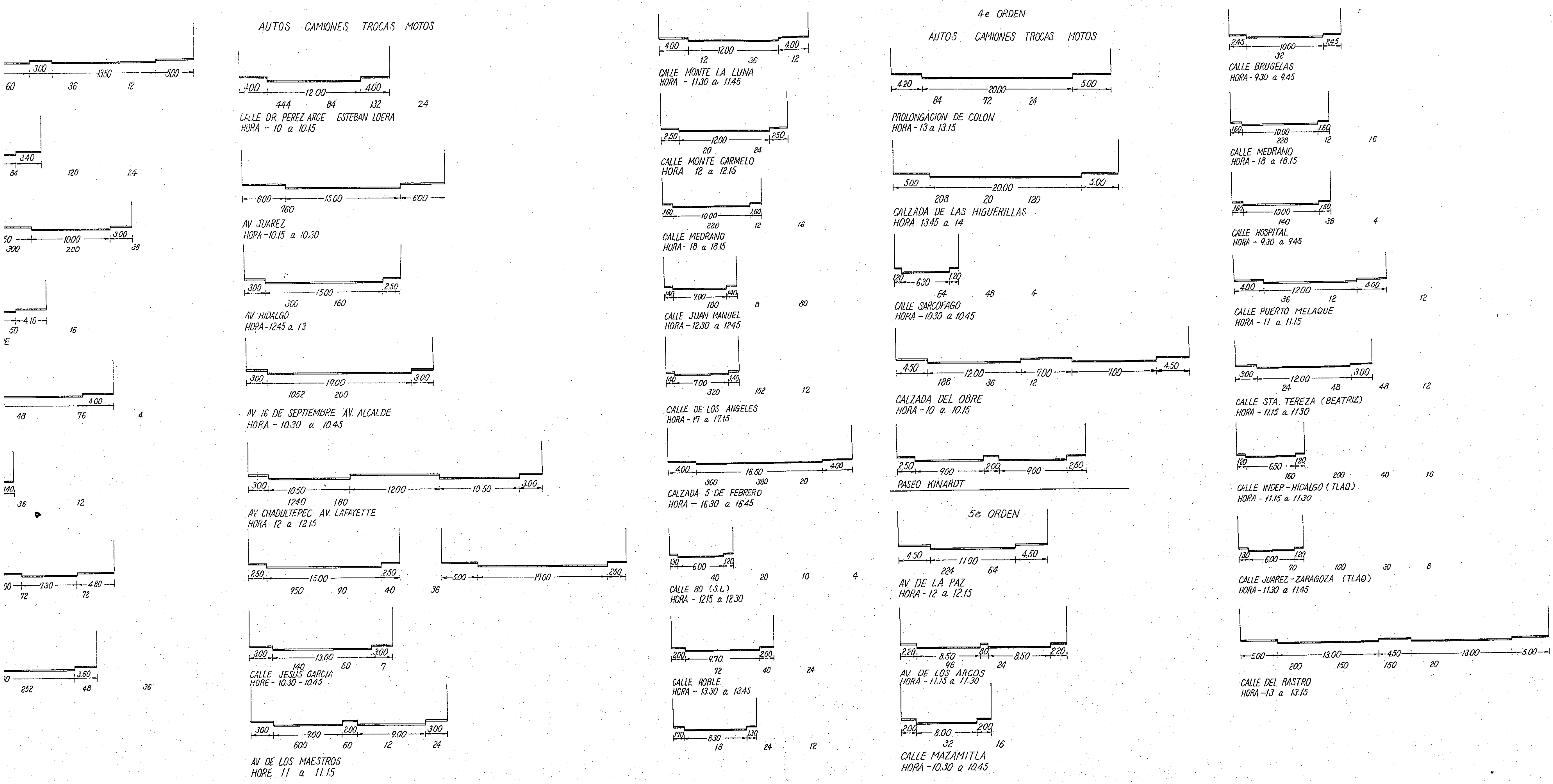


CROSS SECTION OF ROAD



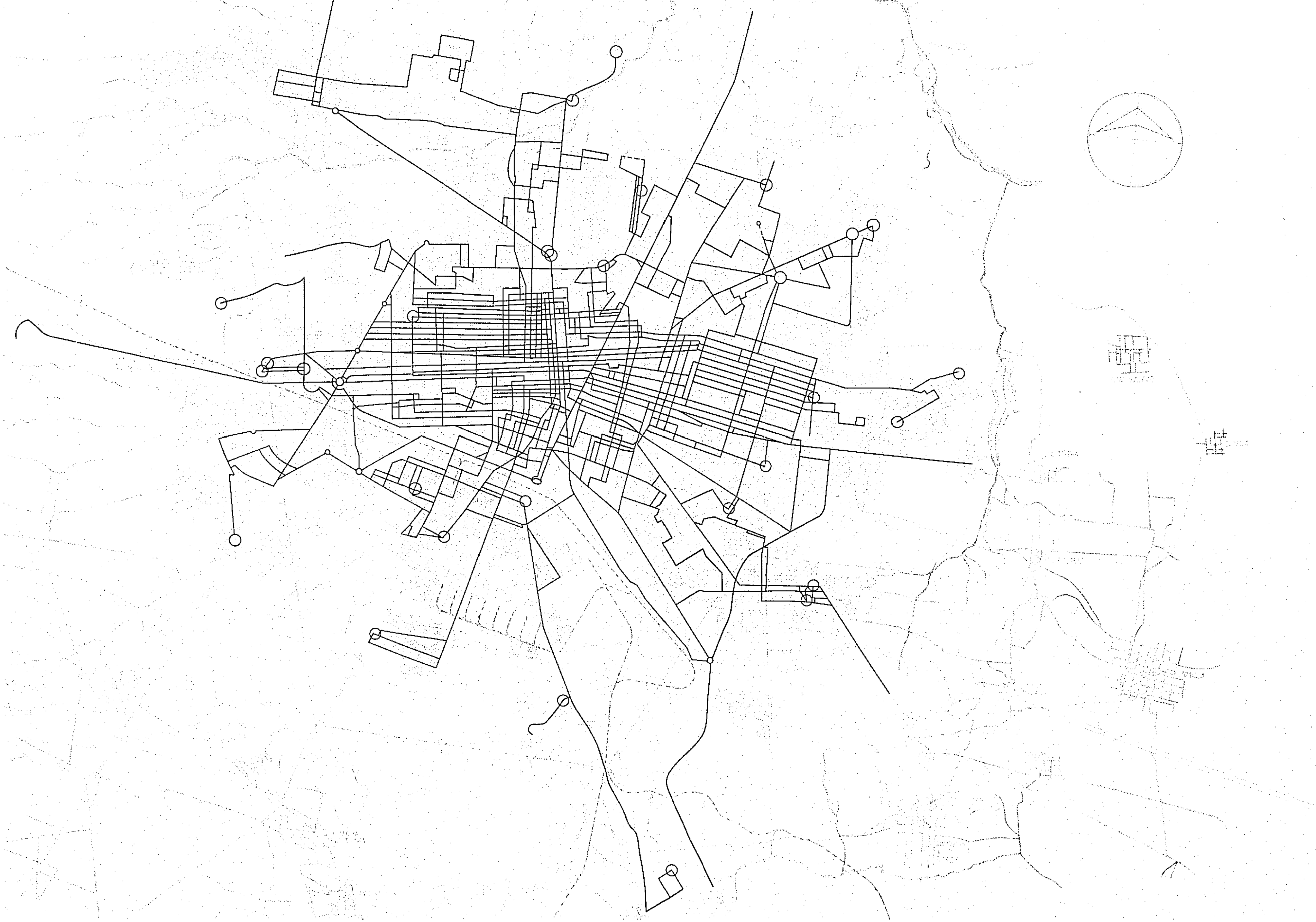
CROSS SECTION OF ROAD

Fig 2—8—2



BUS-ROUTE NETWORK OF GUADALAJARA CITY

Fig 2—9



LOCATION OF TAXI BUSINESS OFFICES IN GUADALAJARA CITY

Fig 2—10

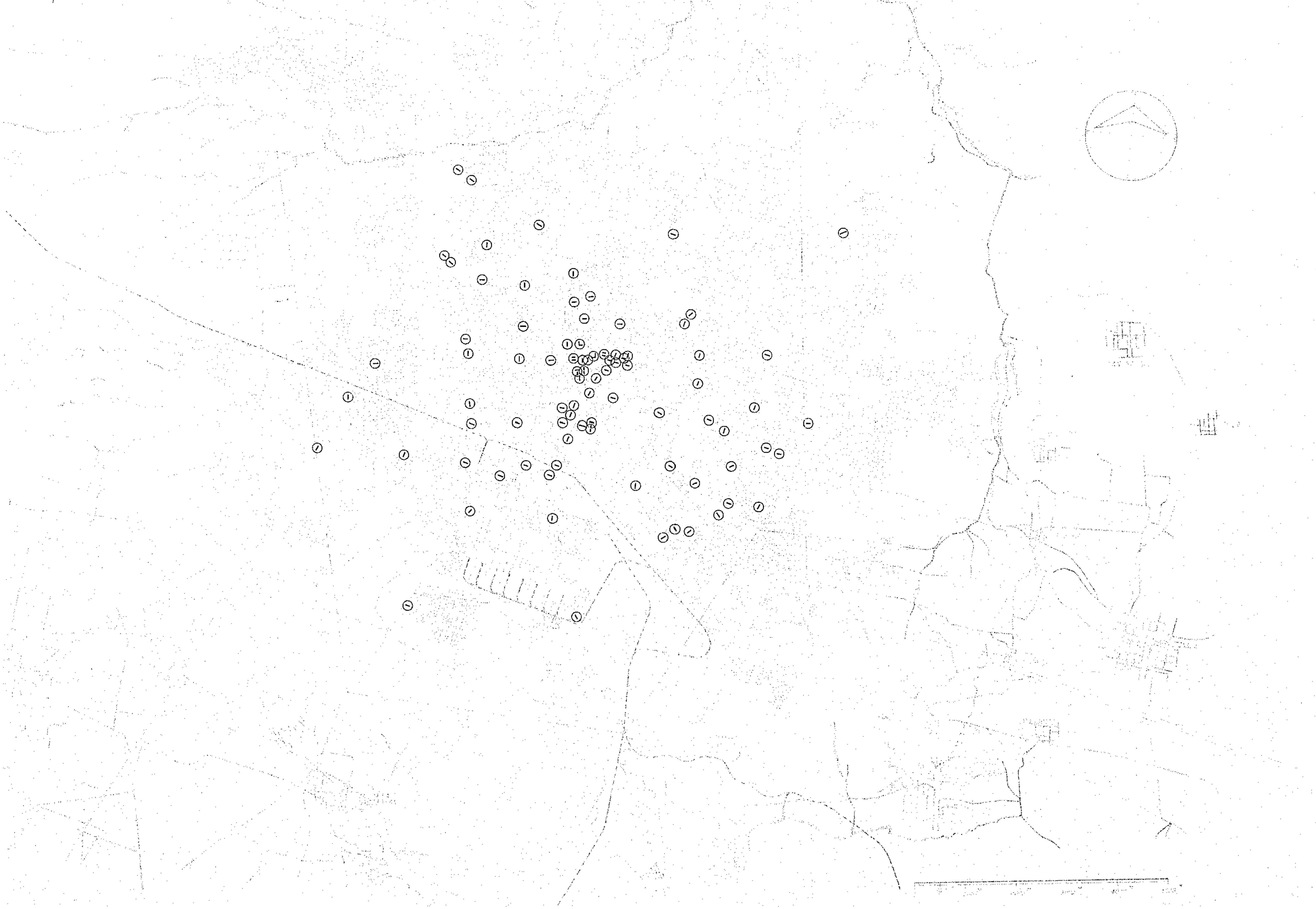
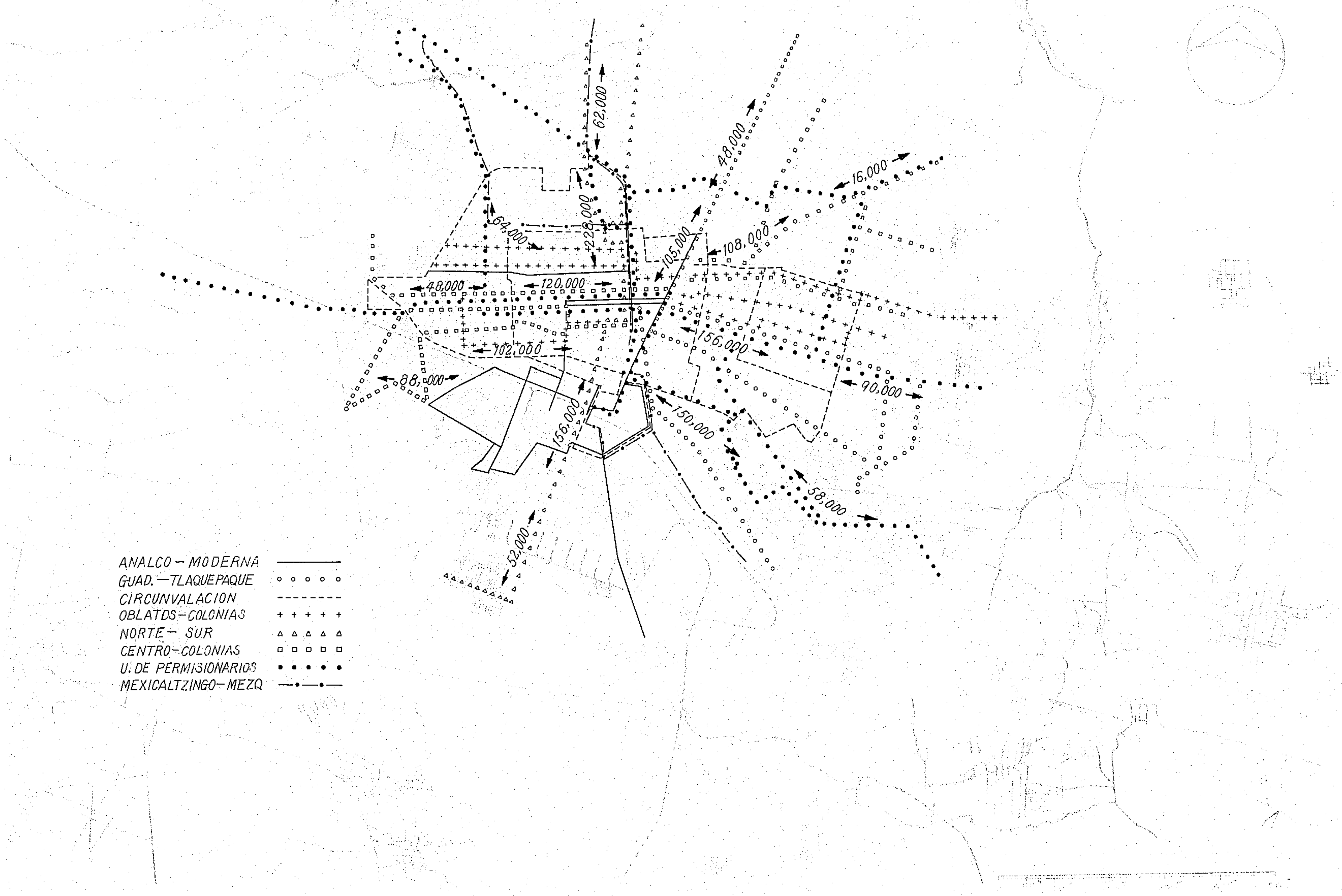


Fig 2—11

TRANSPORT NUMBER OF PERSONS PER DAY OF AUTO-BUS IN GUADALAJARA CITY



CHAPTER III. THE PROSPECTS FOR THE FUTURE OF JALISCO STATE AND GUADALAJARA CITY

1. Population and density of population (See Fig. 3–1)

The population of Jalisco State is likely to continue to increase rapidly in view of its location in the Republic of Mexico and other geographical and topographical conditions.

The Jalisco State authorities estimate that the State's population will rise to 3,980,000 in 1970, the highest among the 29 states of the country and accounting for 8.2 per cent of the total population of Mexico.

Taking into consideration the upward trends of population in the 18–year period between 1950 and 1967 and the recent three year-period between 1965 and 1967, we estimate the State's population at 3,850,000 to 4,000,000 in 1970 and at 5,500,000 to 6,600,000 in 1980.

Guadalajara is expected to see a further increase in population and population density as the commercial and industrial center of Jalisco State in view of its advantageous geographical position and effective land use.

We estimate that the population of Guadalajara will increase to 1,640,000 to 1,740,000 in 1970, 2,150,000 to 2,700,000 in 1975, and 5 years after in 1980 to 2,670,000 to 4,100,000, i.e. about 3,400,000, which is about 2.5 times the 1,400,000 population in 1968.

From the above estimates, the density of population in Jalisco State will be 49 persons per square kilometer in 1970 and 74 persons per square kilometer in 1980.

The population density for the whole area of Guadalajara City was 7,500 persons per square kilometer in 1968. Since only about 50 per cent of the total area has been urbanized, the population density for this area was 14,900 persons per square kilometer, almost as high as the average population density of 15,000 persons per square kilometer for the urban area.

The urban areas of Guadalajara will be modernized by redevelopment and other improvement schemes and will have a further intensified population density. However, it also can be assumed that per person floor area requirement will increase further in the future. In view of such trends of population, this city will probably expand largely into suburban areas including Tlaquepaque and Zapopan.

Now, the population in 1980 of the urban traffic zone of Guadalajara (the future population of Guadalajara plus the future populations of the completed urban areas of Tlaquepaque and Zapopan) can be estimated at some 3,500,000, an increase of about 100,000.

Suppose the urbanization of this city progresses with its average population density being maintained on the level of 15,000 persons per square kilometer, the city areas will be covering about 230 square kilometers, stretching about 8.6 kilometers outward from the downtown area. This is close to the standard pattern of well-balanced urbanization for many other cities over the world.

2. Industries and employed workers (See Fig. 3–1)

Jalisco State will most likely have continuing expansion in agriculture and industry in view of its geographical, climatic and transport conditions. Guadalajara, the administrative, economic and cultural center of the State, has particularly high degrees of concentration of manufacturing industries (48%) and processing industries (82%) and this tendency is expected to be intensified further in the future, and we estimate that Guadalajara City will develop as an economic and industrial town.

According to the statistics for the 18 years from 1950 to 1967, employed workers accounted for 30 per cent of the total population of Jalisco State and 33 per cent for Guadalajara City, which, however, has risen up to 38 per cent and is estimated to reach 40 per cent by 1980.

The employed population of Guadalajara as a metropolitan area, which was 450,000 in 1967, is estimated to increase to 670,000 in 1970, 930,000 in 1975 and 1,400,000 in 1980, which is about three times the number of employed population in 1967.

3. **Urban structure**

Guadalajara has an urban structure of the mononuclear type and is continuing a very rapid growth into a large city due to the accelerated concentration of population and industry. The steadily expanding city areas of Guadalajara have already spread beyond its administrative boundaries into Municipio Tlaquepaque and Zapopan, absorbing the city areas of these districts, and are still continuing to extend outward. It is already having some phenomenal characteristics of a large city; greatly extended commuters' bus routes to carry those who live farther and farther out in the suburbs and work in the downtown areas, increased stagnation of the flows of traffic in the main arterial roads in and around the city's center, and the deterioration of the environmental conditions in the overcrowded residential areas.

The Government of Jalisco State and Guadalajara City have the following plans for effective land use, road networks and traffic control, which are all essential factors to be taken into consideration in formulating a plan of building new urban transport facilities.

1) Use district plan

(1) Exclusive commercial area and commercial area

The "exclusive commercial area", which has been so designated by Guadalajara City, is situated in the downtown area and it is not only the central administrative function center of Jalisco State but also the city's business and information center as well as the centers of shopping and leisure spending activities. With the continuing increase in population, the buildings in this area are likely to become larger and taller in the future. The "commercial areas" stretching along the main arterial roads running through this city are expected to continue to make intensive development as sub-centers of the city.

Guadalajara City now has a redevelopment plan, covering 4 square kilometers, including a plan of road development as shown in Fig. 3–2. The City has a plan of dispersing the urban areas and work is in progress on the construction of a sub-center of commercial and business activities in Comercial Lafayette about 3 kilometers west of the downtown area of the city.

(2) Industrial district

A Zona Industrial is set aside, though not specially designated, in the southarn part of the city and factories are now being built in this area. In view of its advantageous geographical location, this city will grow into an important industrial center of the inland areas and continue to expand in the future. However, it is not much desirable to bring industry too close to the urban areas from the standpoint of public nuisances caused by factories.

So, it is advisable, as being planned by this city, that efforts are made to site new industrial projects in the areas beyond the outer loop road, about 15 kilomets southeast of the city.

(3) Residential areas

The residential areas of this city have been divided into three classes-upper, middle and ordinary residential areas. Housing projects are now in progress by the State, City and private enterprises mainly in the areas around the city as shown in Fig. 3–3 with the special housing loans received from banks. As Guadalajara expands more and more into a large city, its urban areas will most likely tend toward the more effective land use by building many-stories buildings rather than spreading horizontally while the buildings becoming lower in the outer areas. This is the most probable pattern of urban development city will take as it grows outward. In order to establish an efficient system of urban transport, it is considered recommendable that transport centers (bus terminals and automobile parking places) centering around subway stations in the suburban areas (about 5 to 7 kilometers away from the downtown area) and housing projects are developed around them.

2) Road and street plan (See Fig. 3–3)

The road development plan envisions teh following arrangement of traffic routes. The main arterial roads come into this city from five directions. National Road No. 15 coming in from the west and southwest and National Road No. 80 from the southeast are furnished with bypasses at Calzada de Las Torres in the southern part of the city so that the thorough traffic may be separated from the urban traffic within the city. State Road 11 coming from the north and some other roads coming from the same direction are met by the inner loop road running halfway between the downtown area and the suburban areas. The roads inside the loop road link with the five arterial streets in the east-to-west direction and with the 10 arterial streets in the north-to-south direction.

In the suburban areas is planned an additional loop road to cope with the future expansion of the urban areas. Outside the loop road is planned Amillo Periferico, an outer loop road, for linking the communities around the city, and part of this road is already under construction.

One-way traffic control is imposed on the streets of the urban areas and parking meters are set up in the arterial roads to facilitate smooth flows of traffic. However, the stagnation of the flow of road traffic is already observed in and around teh congested downtown area. In view of the rapid increase of suburban population in the future, the control of traffic is expected to become a increasingly difficult problem because the commuters and the day-scholars will have to depend on the bus service for their journeys to and from the downtown area.

So, it is necessary to set up urgently a stopgap traffic control system before the completion of an efficient mass transport system in this city. Besed on this plan, parking of cars should be restricted or forbidden in some specific areas for specific parts of the day, the one-way traffic control be intensified, turning to the right be forbidden, proper lane marks be provided, a systematic signalling method be adopted, and it also will be necessary to classify the vehicular traffic into some categories according to their importance and impose a traffic control to give preference to some specific types of transport (the establishment of traffic routes exclusively reserved for use by buses, proper arrangement of bus stops, prohibition of truck traffic during the daytime, for example). There is more strict traffic control such as the prohibition of vehicular traffic in the midtown section and some specific areas where there is particularly heavy pedestrian traffic. These measures will most probably have to be enforced in the near future.

4. Basic conditions for future planning

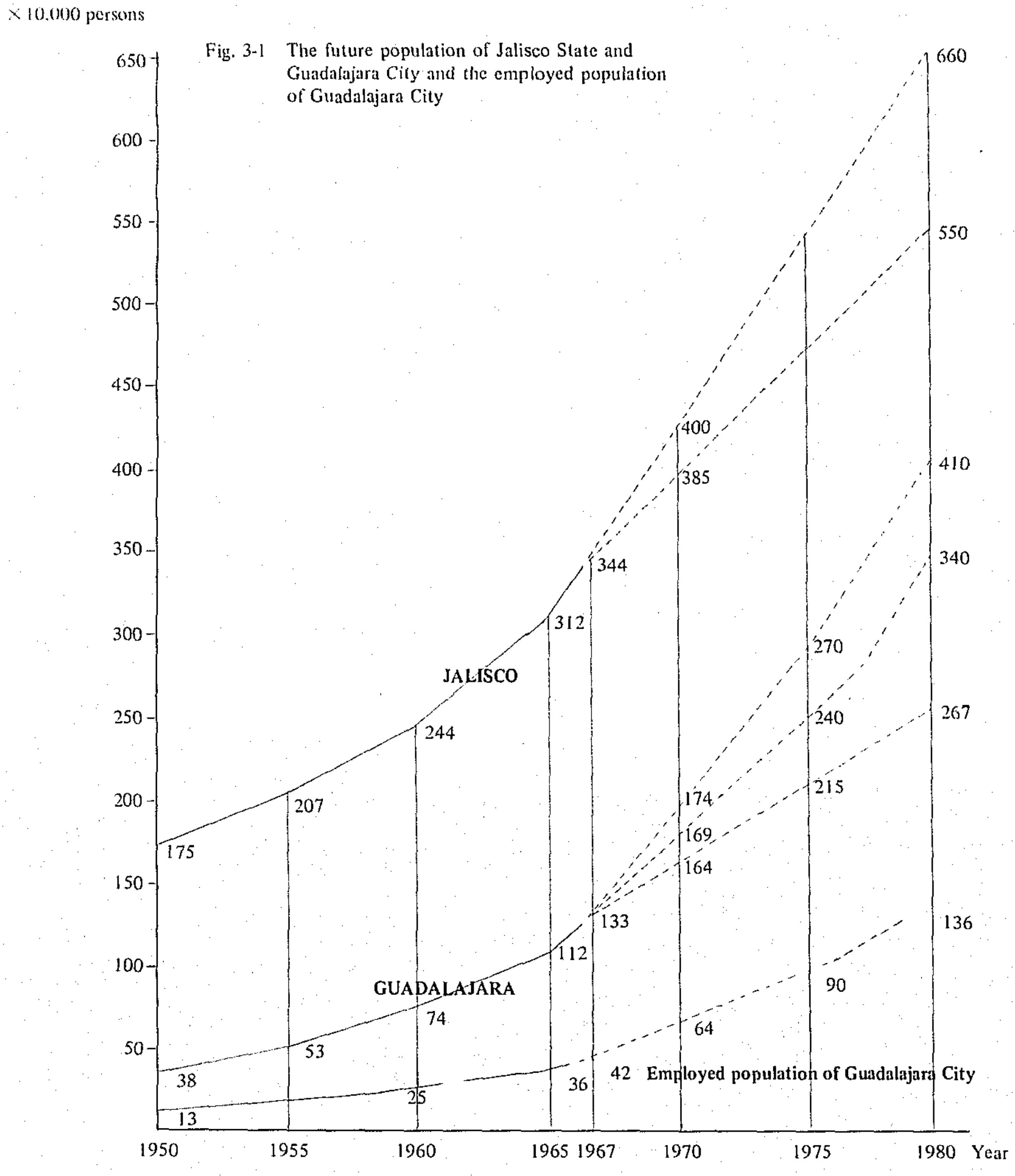
The basic conditions for formulating the future plan for the urban structure of this city are as follows.

(1) Since Guadalajara City is expected to continue its growth, absorbing adjacent manicipios, it is necessary to regard the city as Greater Guadalajara including the wide areas of the outlying suburbs.

(2) Owing to its topographical and urban structural conditions, Guadalajara has seen urbanization of its western and southwestern parts in particular and is expected to make farther development in this direction in the future. The eastern and northern parts of the city have some restrictions due to their topographical conditions and the southern part also have some restrictions due to its urban structural conditions but these areas will also continue to develop for the foreseeable future. It is necessary to make a land use plan at the earliest possible time, taking into consideration all these trends of urbanization in this city.

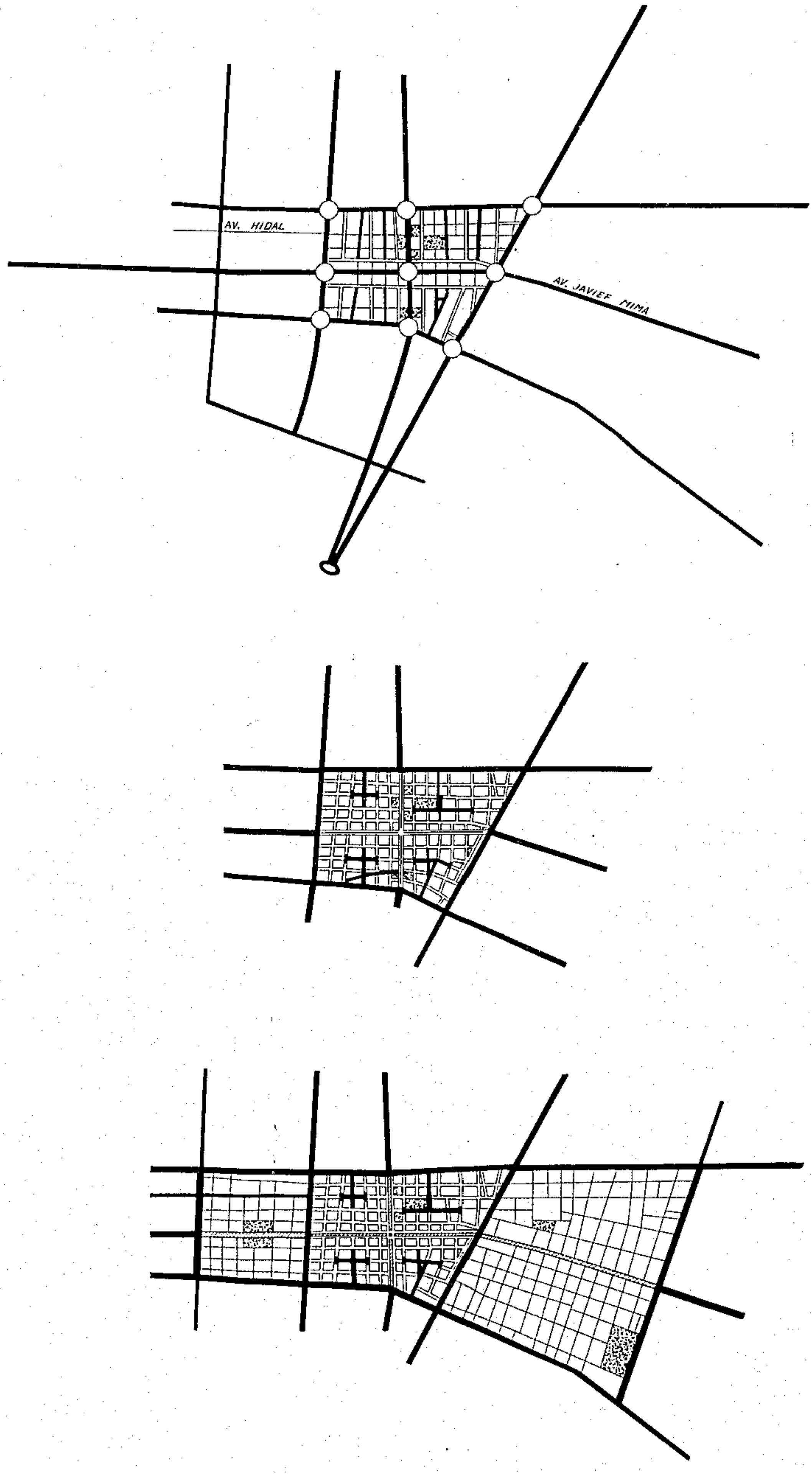
(3) Guadalajara has been and will remain a city of the mononuclear urban structure. However, it is expected to have a more complex urban structure with many sub-centers. So, in siting such urban sub-centers it is necessary to take into careful consideration the future land use plan and transport facilities.

(4) The transport system of Guadalajara of today comprises buses, taxi and privately owned automobiles. It is of urgent necessity to consider the creation of an efficient transport system consisting mainly of high-speed mass transport means, because, as the urban structure grows larger, the travelling distances will become longer and there will be greatly expanded demands for traffic between the center of the city and the outlying areas.


× 10.000 persons
Fig. 3-1 The future population of Jalisco State and Guadalajara City and the employed population of Guadalajara City
650
600
550
500
450
400
350
300
250
200
150
100
50
660
550
400
385
410
344
312
340
270
JALISCO
240
267
244
207
215
174
169
164
175
133
136
112
GUADALAJARA
90
74
64
53
38
36
42 Employed population of Guadalajara City
25
13
1950
1955
1960
1965
1967
1970
1975
1980
Year

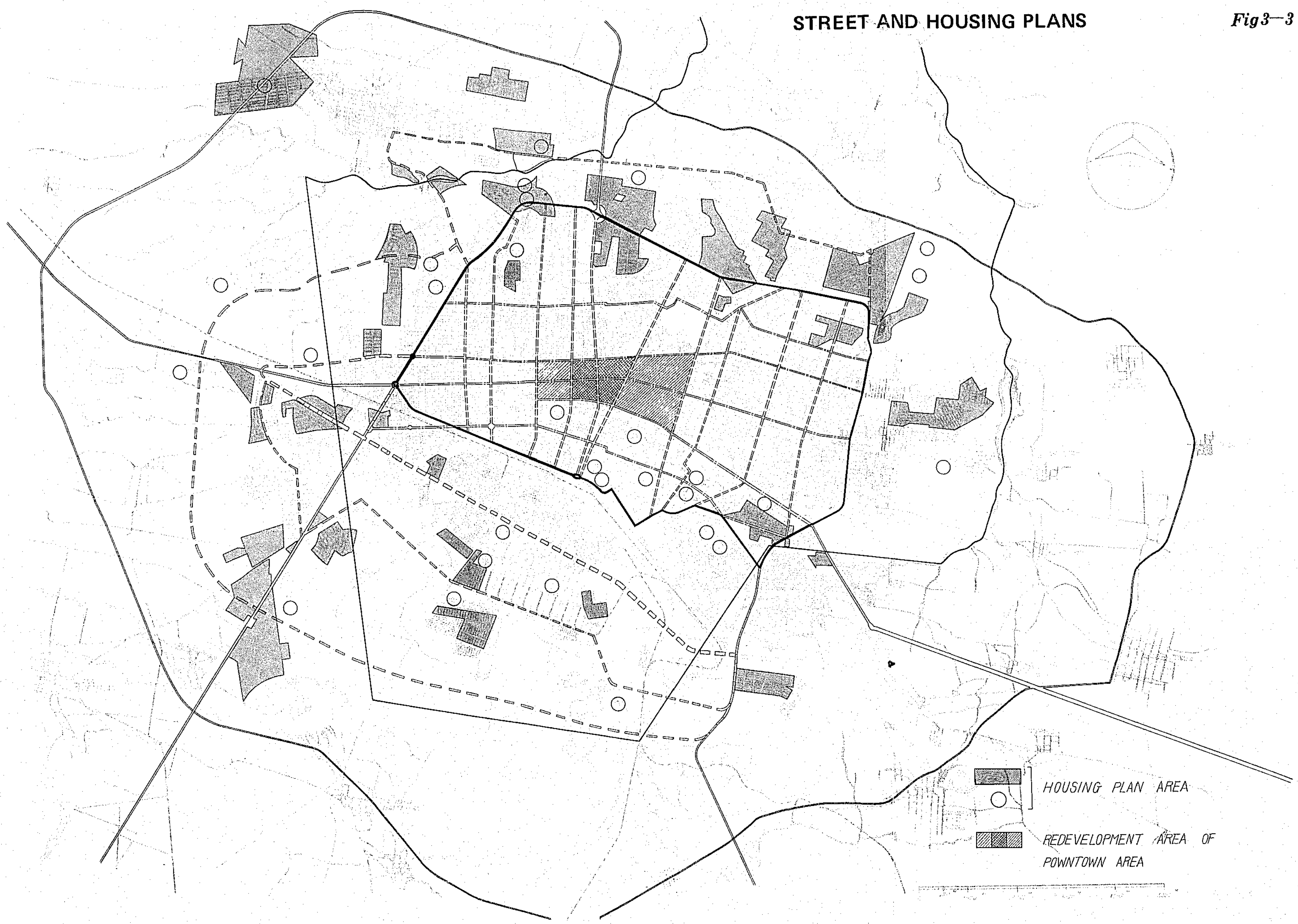
RE-DEVELOPMENT PLANS OF DOWNTOWN AREA

Fig 3—2



STREET AND HOUSING PLANS

Fig 3—3



CHAPTER IV. URBAN TRANSPORT SYSTEMS

1. Introduction

The urban traffic situation varies according to the history and national character of the countries or regions.

Each city has a transport system best suited to meet its characteristic needs. Some cities depend mainly on the subway or other high-speed railroad services while others relying predominantly on motor-cars. Very few cities are satisfied with their existing transport systems and are constantly seeking for a better system of transport to meet their traffic requirements that are changing in both quality and quantity.

2. Types and characteristic features of different urban transport systems

The high-speed mass transport means conceivable for use in a big city are of the following types and characteristic features.

1) Types
   (1) Surface railway
   (2) Elevated railway
   (3) Underground railway (subway)
   (4) Monorail
   (5) Trolley-bus
   (6) Omnibus
   (7) Other vehicles

2) Characteristics

(1) Surface railway

The surface railway is built when the land is relatively flat with not much topographical obstacles on the ground. This type of railway system is the cheapest to construct. In completed city areas, however, the construction of a railway system is conceivable only when use is made of the existing railway line or when it is newly built in the suburban areas away from the crowded city areas.

The crossings prove troublesome when high-speed surface trains are operated in tight schedule. So, when the railway tracks run on the level ground, the road must be elevated where it crosses the railway line. In the crowded city areas it is customary to use the elevated or underground railway.

(2) Elevated railway

The elevated railway system is used most often when the railway tracks and roads cross continually at different levels.

The elevated railway uses either a bank or viaducts to carry the tracks above the streets. The choice between the two methods is made according to the environmental and economic conditions of the area in which the proposed elevated railway line is built. Generally speaking, the bank is suitable for use in a suburban district where there are not many houses and the railway traffic is not so much a nuisance to the resident in the neighborhood, the price of land is comparatively low and good-quality earth and sand are easily available from nearby sources. But it is not recommendable in the city area crowded with houses.

The viaduct is better suited in use where the elevated railway runs through an area crowded with houses and other structures.

In order to offset the high price of land to some extent, the space under the viaduct is sometimes used for shops, warehouses and the like.

However, it is extremely difficult to build a viaduct-elevated railway in the midtown section of a city where there are many permanent structures and tall buildings because it is difficult for the viaduct to make a sharp curve due to the alignment requirement of the railway and cosequently it becomes necessary to remove the obstacle on the ground.

When a road is so wide as to allow the construction of the supporting pillars, it is possible to build an elevated railway above the road.

When built in a crowded cityarea, the elevated railway has the following disadvantage. Since the viaduct must support the ballast of the tracks, it inevitably has a massive structure and consequently the elevated railway gives a sense of oppression to the neighborhood on its both sides, impairs the beauty of the surrounding areas, and the noise and vibration of the train cause nuisance to the residents in the neighborhood.

(3) Underground railway (Subway)

The subway is already in operation in 37 cities around the world and 28 cities have more than 10 kilometers subway lines in total.

The subway system is used when it is desirable to make use of the underground space under the roads or when it is necessary to pass the train under some obstructing structures existing on the ground. This is the most recommendableform of high-speed mass transport for urban districts.

In contrast to the ground-level or elevated railways which occupy considerable space on the ground for their tracks and stations, the subway has all these facilities under the ground and does not interfere with the road traffic and does not affect the appearance of the surrounding districts. For these reasons, the subway is favorably received by the resident in the neighboring areas. On the other hand, however, it has the disadvantage that it costs much higher than the surface or elevated railway and takes a longer time to be built.

The construction cost of a subway is so high because its underground structures must be large and solidly built, the construction of a tunnel produces great amounts of excavated earth and it requires many incidental work such as the treatment of the previously existing underground installations like gas and electricity mains and the road surface covering.

Generally, the subway construction cost, when the cost of land procured is not included, is about twice as high as the cost of the elevated railway and even after it is put into operation it requires extra expenses such as ventilation, illumination and drainage, as compared with other forms of railway systems.

The noise of underground train operation has recently been reduced considerably by various improvements of rail and cars and the use of sound-and shock-absorbing materials.

In Paris the underground railway trains run on pneumatic tires. This type of tires, however, has some problems regarding maintenance and puncture of the rubber tire as mentioned later.

(4) Monorail

Monorail is a special type of railway in which the track consists of a single rail to make an economical use of space. There are about ten monorail lines now in operation for carrying passengers in the world, two of which have a total length of more than 10 kilometers.

The monorail trains are of two types, the straddle type (in which the train runs straddled on a specially designed single-rail track) and the suspension type (in which the train is suspended from a specially designed trackgirder). The monorail is suited for construction over the roads or canals because their track girder and and supporting pillars can be made slender compared with the elevated railway.

The monorail structures are less massive and obstruct a less amount of sun light than those of the ordinary elevated railway, and the monorail train makes less noise than a train running on an elevated track. For these reasons, the monorail causes less damage to the surrounding areas.

The monorail costs less than the underground or elevated railway.

There are the following reasons why the monorail has not been used so widely in many countries of the world inspite of its advantage that is to make efficient use of space.

The first reason is that the monorail has not yet proved its usefulness as a mass transport means.

A monorail line has long been in operation as a substitute for a tramway in Wuppertal of Germany. Most of the monorail systems built later were for tourist purposes. The only instance of monorail being used as a high-speed urban transport system is the Tokyo Monorail which links the Tokyo International Airport and the midtown section of Tokyo.

The monorail systems previously in use are inferior to the subway in transporting capacity, on which research and development efforts are now being made for the monorail.

The second reason for the greatly limited use of the monorail at the present time is that full advantage can be taken of the monorail only where the space above the raods or canals can be utilized effectively while there are not enough roads and canals suitable for this purpose in the existing cities.

The monorail has a disadvantage that if a train is to be composed of many cars to have a total length as construction cost of a tunnel for the monorail would be somewhat higher than that of a tunnel for the subway do because the monorail system must be furnished with its station facilities such as platforms, concourses and pedestrian bridges constructed on the road.

This being so, the subway system is predominantly useful in the district where great importance must be attached to the preservation of the urban environment and the space above the roads. However, the monorail affords a great saving in construction cost and time that it is advantageous where the passenger traffic is relatively light, it is not necessary to be linked directly with any existing railway line, and the use of the space above the roads and canalas is permissible for the construction of a monorail line.

The monorail is an independent and special-type railway system and is carried on viaducts in principle. However, it can be run through an underground tunnel in the busy midtown areas or hilly district. The construction cost of a tunnel for the monorail would be somewhat higher than that of a tunnel for the subway because the former must have a greater height than the latter.

(5) Trolley-bus

The trolley-bus has developed as a popular surface transport means for urban areas thanks to its advantage that it is free from exhaust gases and noise, capable of carrying many passengers at one time and it gives good acceleration performance. However, since it needs overhead wires installed above the roads as in the case of the tramway, it impaires the beauty of the surroundings and its maintenance and repairing costs run high.

The ordinary type of bus has lately been greatly improved in perormance and become larger in size to such an extent that it is as good as the trolley-bus. As a result, the trolley-bus now has less importance than before as a public vehicle in urban districts.

(6) Omnibus

The omnibus has been playing a very important role as a very popular form of public conveyance in many cities of the world. However, the bus also has some inevitable disadvantages. It produces noxious exhaust fumes and annoying noise, causing damage to urban life. The average operating speed of buses has declined rapidly in big cities where the road traffic is extremely congested due to the enormous increase in the number of motor-cars and consequently it takes for a bus much longer time than before to reach its destination and this has considerably decreased the number of the users of bus services in some places. More than that, there are many bus services which have to raise fares by a large margin due to the financial difficulty resulting from the lowered operating efficiency and the increased personnel expenses.

Even under such circumstances, the bus is most likely to continue to play its role as a convenient means of transport supplementary to other forms of high-speed mass transport such as elevated or underground railways until some new and better form of public conveyance appears to take its place. Such being the case, it is necessary to make efforts to maintain and further develop the bus service by taking various measures such as setting up a traffic rule to give preference to the bus over other types of vehicles or creating the roads reserved exclusively for buses so that the bus services and other basic transport systems may be well coordinated to establish a network of highly satisfactory public transport services.

(7) Other forms of public transport

Various other forms of public transport now being studied in many countries of the world will be discussed briefly below.

Rail-bus: This is a special type of bus equipped with wheels for running on the railway track so that it can be operated not only on the roads but also on the railway tracks. These buses are operated at high speeds, singly or serveral buses joined together, on the existing railway lines or on those newly laid in the areas where the bus traffic is most heavy. They are switched to ordinary roads near their destrinations. This system of bus traffic requires less land space than ordinary expressways and is able to operate a far greater number of buses. This system is now being studied in Japan and the United States of America.

Electromobile: This is equipped with special batteries and has a high rate of acceleration and deceleration of speed. This provides smooth running and is an ideal type producing no noise and exhausts. A large capacity of battery, however, is required to put it into practical use. Various countries are competing in the study and research thereof.

Linear motorcar: The principle of this new transport system is that the rotor and stator of an electric motor take the places of the railway track and the vehicle running on it. This vehicle can be operated at a very high speed (about 300 to 500 kilometers per hour) and best suited for long-distance intercity transportation. This system is now being experimented in Japan and France.

Moving footway: This is an electrically driven rubber coveyer belt on which passengers are carried. A large-scale moving footway can be built on an elevated level in the urban areas. The moving speed is up to 15 kilometers per hour. The passenger can get off at his destrination station by stepping to the decelerator moving in parallel to the moving footway.

This system of public transport is suited for carrying a large volume of traffic over short distances and is now being studied in Japan and Britain.

CHAPTER V. THE URBAN TRANSPORT SYSTEM RECOMMENDED TO GUADALAJARA

1. Types of transport facilities

We carried out a study to find out what type of urban transport system is most recommendable to Guadalajara City. The results of the study revealed that this city and its suburban areas have been developing very rapidly and the population has expanded at an accelerated speed and this makes it necessary to provide some form of high-speed mass transport system. We made studies on the previously discussed types of public transport in order to find out what type of transport facilities is best suited for this city.

This city's central areas and suburban districts have considerably different conditions. It would be appropriate to consider mainly the transport for the city areas and adopt more economical means of transport for the suburban districts.

The city of Guadalajara including its circumference areas is estimated to have a total population of some 3,500,000 and an employed population of some 1,400,000 in 1980 or 11 years from now. By this time, the urbanization of the city's central areas will have made a considerable progress to become an improtant administrative, industrial and commercial center with many-storied modern buildings rising along the streets and large numbers of people will be travelling to the central areas from suburban districts to go to work or school, for business or shopping.

As a result, the passenger traffic between the business center within a radius of about one kilometer around the crossing of the midtown throughfares of Calzada Independencia and Av. Juarez and the outlying suburban areas will grow very heavy compared with other section of the city.

The roads in this part of the city are already so much congested that overhead pedestrian bridges are set up on some streets to separate the vehicular traffic from the pedestrial traffic and the one-way traffic rule and restrictions on the passage of buses through main streets have been imposed to ensure good trafic flow. It is impossible to set up a new high-speed mass transport system on the street level under such circumstances.

Now we come to the comparison of the elevated transport system and the underground system. In the case of the elevated system, we have decided to choose the monorail for the comparison because it is more advantageous than the ordinary elevated railway in construction cost, noise annoyance and other illeffects on the neighborhood. The road width required for the construction of a monarail is determined by the width of the monorail station facilities: more than about 22 meters of width is needed. In this respect the main roads of this city are qualified for the construction of monorail lines. However, since the stations must be built at very short intervals and there would be many crossings of the lines in the midtown section as was previously stated, the street would be completely covered with the monorail structure where there is a station with the result that it would be so shadowy that the automobiles would have to turn on their headlights even during the daytime. More than that, the air polluted with auto exhausts would remain stagnant to deteriorate the condition of environment sanitation for the neighborhood.

With the expansion of the city, there would arise need for extending the lines out into the suburbs in the future. In order to meet the future requirements, it is necessary to plan and design the monorail system so that it can be strengthened in capacity to some extent when needed in the future.

Research and development efforts are being made to increase the capacity of the monorail. At the present time, however, the underground railway is superior to the monorail in transporting capacity and is thought to be capable of better coping with the future increase in the traffic demands in the future.

It would be necessary to make the most effective use of the vailable road space in the crowded city areas by using the space above, on and under the road surface. So, it is advisable that the space above the roads is kept vacant to provide room for the future development of the possibilities of the city. This will make possible to build urban expressways or elevated monorail lines above the roads in the future.

We have so far discussed the disadvantages of the monorail. No such disadvantages are found in the case of the underground railway. In this respect the subway system is ideal form of high-speed mass transport in urban districts but it has a disadvantage of being high in construction cost.

Any organization responsible for the construction would have to be prepared to suffer some financial deficit. In many countries the subways are given subsidies from the Government (Federal Government) or Prefecture (State) or long-term low-interest loans of exemption from various taxes.

Guadalajara City has introduced a system in which the people receiving benefit from roads and streets are obligated to pay dues to help finance the management of them. This system should be applied also to the spheres of influence of the stations when a subway line is constructed.

This city seems to have favorable conditions for the construction of a subway system: the good sub-soil will reduce the construction cost and there will be considerably high frequency of use of subways due to the habits of living of the people of this city.

Generally speaking, when a high-speed mass transport system is built in completed cities, except a city where a tunnel can be excavated 40 to 50 meters below the ground surface by using a special engineering method, use is made of the space above or under the roads or rivers in many cases for economic reasons and consequently the need for purchasing privately owned land is limited only to a few places such as where the line forms a curve.

Since Guadalajara has made a considerable progress in city planning and has well arranged network of streets, it is well advised to make full use of the street.

When constructing a subway, it is advisable to construct an underground passage that serves also as a multi-purpose underground duct and an underground pedestrian crossing. This will make it possible to carry out relatively economically the extension or repair work on the gas and electricity mains and sewerage and water-supply systems. It would not be impossible to designate crossing prohibited places on the road for pedestrians along the underground passage to help relieve the traffic congestion.

It would be advisable to build an elevated monorail line to play the role of a transport system, halfway between the bus and the subway where not much increase in traffic volume is expected such as the loop street of Circunvalacion and in some sections of the city.

For the above reasons, we the mission recommend to construct a "subway system" mainly running under the ground surface in this city.

2. Types of subways

The wheels of the underground train are of two types, steel wheels that have been used for many years and the pneumatic rubber wheels that are now being developed.

The underground train with rubber wheels was put into practical use for the first time in 1957 on No. 11 route of the subways in Paris.

The Paris-type underground train is somewhat superior in operating performance such as adhesion resistance and acceleration as well as passenger service such as the prevention of noise. On the other hand, this type of subway train has the following disadvantages. The usable life of a rubber tire is far shorter than that of a steel wheel. Apart from the regualr track of rails for the rubber wheels, an additional guiding track is needed and this increases the cost of construction and maintenance. The rubber wheeled train can be operated by using the steel wheels even when a rubber tire has been punctured but such operation of the train would most probably interfer to the normal operation of the subway service. The wheels, axles, tracks for rubber tires and their accessories are all of special design and therefore the previously used railway engineering techniques and equipment parts are useless so that it is necessary to procure patented parts by paying constly royalties. Since it is, needless to say, impossible to connect a rubber-wheel railway line to an ordinary railway, the special type of railway track must be used for the entire network of the subway lines.

The foregoing subject is discussed in fuller details below.

The advantages of the rubber-tired train can be summarized as follows:

(1) Because of the greater adhesion between the wheel and the concrete track, the train can have a greater acceleration and deceleration performance, thus making it possible to increase the normal operating speed of the train.
(2) The noise that is caused by the contact between the wheel and the track is reduced.
(3) The maximum gradient of the track can be increased.

The acceleration and deceleration mentioned in the above (1) must be limited properly from the point of view of not only the efficiency of the vehicle but also the comfort of the passengers. The rubber-tired train of Paris has its acceleration increased to 4.8 km/H/S, a permissible maximum beyond which the standing passengers will stagger and fall down. The No. 2 Subway Route of Tokyo is operating all the trains at 4.0 km/H/S. This is not due to the limits of performing efficiency of the vehicles but for the safety of the passengers because it is compelled to carry passengers more than 200 per cent of the fixed capacity. In this city (Guadalajara), too, the number of users of subways will increase so much that it will be necessary for the train to carry passengers nearly to the utmost limit sometime in the future and then the acceleration of the train will have to be limited to protect the safety of the passengers with the result that the advantage of the rubber-tired train will be so much decreased.

The shorter is the distance between stations, the more the normal operating speed of the train is governed by the accelerating and decelerating performance of the train. However, a difference of 0.8 km. H/S. in the acceleration and deceleration will not have so much influence on the normal operating speed of the train when the inter-station distances are 900 meters or so on the average as in the case of the subways of this city.

As for the noise mentioned in (2), considerable advances have been made in recent years in the techniques of building railway rolling stock and the track, bringing about various innovations such as the penumatic spring and the specially designed elastic locking device to fasten the rail in a fixed position. Owing to such new devices, even the steel-wheel trains of today cause far less noise than the old ones. In the train running along the No. 2 Subway Route of Tokyo, the passengers have virtually no difficulty having a conversation in a normal manner.

It is a great advantage for an urban subway that the vertical gradient stated in (3) can be increased. The maximum permissible gradient for the steel-wheel train is 3.5% while it can be increased up to 6.5% for the rubber-tired train. However, Guadalajara City has no big river and canal and any other topographical features and there is no necessity for a gradient over 3.5%.

The rubber-tired train has the following disadvantages:

(1) The coach construction becomes more complicated because apart from the regular wheels to support the body it is fitted with the guide wheels installed horizontally and the auxiliary steel wheels provided for safety in case of rubber tire puncture or for conducting the train at the railway points.

(2) The usable life of rubber-tired wheel is said to be about 300,000 kilometers. This is shorter than the life of ordinary steel wheels and increases the train maintenance cost.

(3) It is necessary to take such measures as to increase the width or the diameter of the wheel or to increase the number of wheel axles according to the allowable limits of contact pressure of the rubber. The rubber-tired wheel is less capable of bearing the rush-hour load than the steel wheel.

(4) The track has a triple construction consisting of the main rails, the safety steel rail and the guide rail. This will increase the cost of construction and cause railway track maintenance problems in the future.

(5) The rubber tire and the rails have a great coefficient of friction under normal conditions. But, when the rails are wet, the coefficient of friction will change so much that it will become difficult to run the train strenuously in a stable manner and to apply the brakes effectively.

(6) Since the rubber-tired train has a greater train resistance than the steel-wheel train, it is difficult to run the train by momentum. A great traction power is needed when the train is run strenuously and the electric power consumption is so much increased.

At present the rubber-tired train is used for rapid-transit mass transportation only in Paris of France and Montreal of Canada. Experimental trains of this type are being operated in Pittsburgh of the United States and Sapporo of Hokkaido, the northernmost island of Japan.

The subways of Paris had been completed already as early as thirty years ago and it is now urgently needed to replace the old trains and to increase the transporting capacity. The Paris subway system has stations spaced 500 meter apart on the average and the increased accelerating and decelerating performance of the train will be an important factor for increasing the normal speed of train operation and its transporting capacity. If the railway rolling stock and the tracks are to be improved without stopping the operation of the existing lines, the only conceivable method for doing this is what is now being done in Paris, and it would be inveitable to adopt a dual construction for the railway track.

Montreal has St-Laurent River, Le Moyne Waterway and Canals which have great depths and the degrees of the longitudinal gradient limits of the railway track were an important factor for judging the advisability of constructing a subway system itself. Furthermore, the subway planners made it a basic principle that relatively small cars (2.50 meters in width) should be operated at close intervals. The rubber-tired train was considered most advantageous from such a point of view. This system have some advantages for urban transport: The tunnel construction cost is reduced. The tunnel occupies less space under a street. The passengers do not have to wait on the platform so long to take a train.

However, it leave little margin in passenger transporting capacity to cope with the future increase of passenger. For this reason, it is not recommendable as a rapid-transit mass urban transport system for a city like Guadalajara which is expected to develop greatly in the future.

Sapporo of Japan is a city with a population of 900,000. It became necessary for the city to build a rapid-transit urban transport system because it would be unable to handle efficiently the ever-increasing passenger traffic if it had contined depending on the existing tramways and buses. However, the city was financially unable to construct a large-scale underground railway system with a total length of 45 kilometers. So, it was decided to run most of the railways on the elevated tracks. An ordinary elevated railway will raise the construction cost would be high as mentioned before. Such being the case, efforts are now being made to develop a new and relatively small type of rubber-tired train which is different from that of the Paris subways and is suited for use on both elevated and underground railway tracks before the Winter Olympic Games scheduled to be held in the city in 1972.

The Paris subways began to operate rubber-tired trains in 1957. However, it was later found that this type of train was very expensive to operate and maintain. So, since 1967, a new type of steel-wheeled trains equipped with improved shock-absorbing devices have been put into operation when the old subway lines were rebuilt for improvement. It is planned that all the old trains will be replaced with the new trains by 1975.

From what have been so far studied, we intently recommend that the steel-wheeled train be used for the rapid-transit mass transport system in Guadalajara which is expected to grow into a large city with a population of more than 3,500,000 in the near future.

CHAPTER VI. BASIC CONDITIONS FOR SELECTING RAILWAY ROUTES

What is most important in deciding on an underground railway route is to make a careful study and obtain a full knowledge of the existing conditions in the city and correctly estimate the future conditions of the city. Since Guadalajara has no high-speed mass urban transport system at the present time, careful consideration must be given to the effects the newly proposed project would have on the urban structure of the city in the future so that a well-balanced network of subway routes may be formed.

The followings are the basic conditions which should be taken into consideration in planning such a subway network.

(1) All routes must pass through the civic center.
(2) Be helpful in relieving the surface traffic congestion.
(3) Pass through densely populated areas and the areas expected to have an increased population density in the near future.
(4) The terminal of each line is so designed that the line can be extended outward as the suburban districts development in the future.
(5) The subway network is planned in coordination with the street plan.
(6) Passengers can reach their destinations in any direction by changing trains with the minimum frequency of changing trains (once at maximum, if possible).
(7) In consideration of the time the passengers spend in walking between the station and their homes, the inter-station distances should be about 700 meters in the central areas of the city and about 1,500 meters in the suburban districts.
(8) Utmost efforts should be made to avoid using privately owned land, thereby reducing the construction cost and shortening the time needed for completion of work.
(9) Careful consideration should be given to secure land space large enough for setting up sheds and maintenance factories.

These basic rules can be applied to Guadalajara City as follows.

As for the condition (1) above: Guadalajara presently has a mononuclear urban structure and consequently most of commuting, shopping and amusing areas are concentrated to the central area covering only about two square kilometers. Transport demands are heaviest on the routes radiating from the center of the city. The development of suburban areas is progressing outward from the city's center. In view of such conditions, it is necessary for all the subway routes to pass through or at least skirt the edge of the midtown section.

As for the condition (2) above: The subway routes should be so planned as to absorb part of the passenger traffic now being carried by the existing bus service lines so that the subway lines may help relieving the road traffic congestion.

As for the condition (3) above: There is so much demand for transportation between the outlying residential districts and the midtown section that it is desirable for the subway lines to pass through the areas with a high population density during the nighttime and those where housing projects are planned.

As for the condition (4) above: Since a subway line is very expensive to build, it is impossible to extend the route at one time all the way to the suburban areas expected to be urbanized in the future. So, there will be many cases where the extension of subway lines will be required in the future and therefore the possibility of future expansion should be taken into consideration from the viewpoint of engineering and the land required for the line to be extended.

As for the condition (5) above: This is also related to the (2), (3) and (8) conditions. When a subway route is planned, it is desirable that the road development work is done in advance and the road is widened enough to provide a sufficient space for the subway station structures. When necessary, the construction of bus bays and the like should be considered.

As for the condition (6) above: In the case of train service, it is necessary to serve the convenience of the passengers by minimizing the frequency of changing trains to reach their destinations. Changing trains causes the passengers a loss of time and they also do not like climbing up and down the steps to move from platform to platform. The subway network should be well planned so that the passenger can travel to his or her destiantion with the minimum frequency of changing trains and without going a long way round.

As for the condition (7) above: The allowable walking distances between the suburban residences and the nearest stations and between the midtown stations and the passengers' destinations are an important question which must be given serious consideration when planning a subway network. Generally it is desirable to be a distance that can be covered in 10 minutes, that is, a distance of less than 700 meters. However, since the subway network in a city of mono-nuclear type is inevitably composed of the lines radiating from the civic center outward to the peripheral districts and consequently the lines spread wide apart as they stretch more and more away from the city's center. So, the allowable walking distance is also increased inevitably to one kilometer or so in the *circumference* areas while it can be about 500 meters in the midtown areas. The inter-station distance is reasonably about 1.5 kilometer in the suburban districts and about 700 meters in the central areas of the city.

As for the condition (8) above: As urbanization progresses, the price of land generally rises sharply and real estate becomes an object of speculation, *especially in the central areas of a city with the result that* the cost of land takes a considerable portion of the total cost of a subway construction project and often delays the completion of the work. This being so, it is advisable to use the underground space below streets, roads and public parks for building the underground tunnels.

As for the condition (9) above: Since the depot and maintenance factory require a considerably spacious lot of land (about 50,000 square meters), such facilities are built in the suburban areas. In selecting the site of these facilites, careful consideration should be given to the relationships between the subway facilities and the urbanization plan for the areas.

In other words, they must be sited in a way in which they are in good harmony with the roads, houses, green zones and others in the surrounding areas.

CHAPTER VII. SUBWAY NETWORK PLANNING (SEE FIG. 7 – 1)

As was discussed previously in the chapters dealing with the present and future of Guadalajara City and the basic conditions for selecting underground railway routes, this city presently has an approximately mononuclear urban structure and this basic pattern will continue unchanged in the future. In consideration of the urban structure and networks of transport systems in foreign cities with a population nearly the same with that of Guadalajara, such as Boston, Philadelphia, and the representative cities of the world, such as Tokyo, London, New York, Paris and Chicago, we thought it recommendable to this city to build a network of subway lines of radiating type placing centers on the main streets of this city, Av. Juarez and Calzada Independencia. Thus we recommend to build the following four subway lines with a total length of some 54 kilometers and a total of 60 stations.

Route No. 1 (Fig. 7 – 2)

Starting from the new high-class residential areas of Ciudad del Sol and Verde Valle, which is developing fastest among the suburban residential areas of Guadalajara, this subway line will run northward along Av. Lopez Mateos, cross Route No. 3 at Los Acros, run eastward through the high-class residential quarters along Av. Vallarta and Av. Juarez, cross No. 4 line at the Revolucion Park situated west of the downtown area, cross Route No. 2 at the intersection of 16 de Septiembre and Av. Alcalde, the north-to-south streets running through the downtown area, go on to the east to link with Route 3 at Calzada Independencia, a north-to-south main street, go farther to the east along teh shopping center on Av. Javier Mina where there is a large market place, pass through the urban areas crowded with residential areas and reach San Andres. This route will have a total length of some 13.6 kilometers and be the trunk line of the subway network, which will link the southwestern residential areas, the downtown area and eastern residential areas of Guadalajara and intersects all other routes in the downtown area.

Route No. 2 (Fig. 7 – 3)

Starting from the central part of Zapopan, this route will stretch eastward on viaducts above the ground along Calzada Manuel Avila Camacho, taking advantage of the undulating topography on the southern side, go underground of the street near the high-class residential area of Jardines des Country, run below Av. Alcalde to the south, cross Route No. 4 at the intersection of Juan Manuel, an east-to-west arterial street, near the edge of the downtown street, pass by the western side of the Central Cathedral and cross Route No. 1 at the intersection of Av. Juarez, an east-to-west arterial road, go farther southwards and cross Route No. 3 at the intersection of the north-to-south arterial street Calzada Independencia Sur and Av. Corona, go southwards to link with a bus terminal, go round and run eastwards along Calzada 5 de Febrero 29, pass the southern side of Ciudad Universitaria for the benefit of the students to travel to the university, run along Calle Rio Nilo and reach the urban center of Tlaquepaque. This route will have a total length of some 14.8 kilometers and be a highly useful line which will link Zapopan, the downtown area, and Tlaquepaque together and will be connected with many bus routes.

Route No. 3 (Fig. 7-4)

Starting from the new residential area of Prados Vallarta, which is developing fastest in the circumference areas of Guadalajra, after the southwestern section, this route will run eastwards along Av. Vallarta and cross Route No. 1 at Los Acros, run under the street of Circunvalacion along a surface railway line, cross Route No. 4 at the intersection of Av. Colon, a south-to-north street, go farther eastwards to link with the railway station of Estacion de Pasajeros, where turn northwards and run along Calzada Independencia Sur, a south-to-north street, cross Route No. 2 at the intersection of Av. Corona, continue to run northwards to cross Route No. 1 at the intersection of Av. Juarez, an east-to-west arterial streets, in the downtown area, link with Route No. 4 near the Morelos Park, run northeastwards through the densely populated reisdential area of Pablo Valdez and continue to run farther northeastwards along Camino a Huentitan to reach the center of the residential area of Oblatos. With a total length of some 15 kilometers, this will be an important subway line connecting the city's center and its northeastern residential areas.

Route No. 4 (Fig. 7 – 5)

Starting from the industrial and residential area of Lomas de Polanco situated in the southern part of the city, this route will stretch northwards along Prolongacion Av. Colon, pass through the commercial area south of the railway station of Estacion de Pasajeros, run farther northwards to Escobedo, cross Route No. 1 at the intersection of Av. Juarez, an east-to-west arterial street, in the vicinity of the Revolucion Park, run eastwards along Juan Manuel through the circumference areas of the downtown exclusive commercial area, cross Route No. 2 at the intersection of Av. Alcalde, a north-to-south street, join with Route No. 3 at the Morelos Park, run northwards along Calzada Independencia Norte and pass by the front side of the General Security Hospital to reach Jalisco Stadium. With a total length of some 10.4 kilometers, this route will connect the southern industrial district, the downtown area and the northern reisdential areas.

Plan for extension of subway routes in the future:

The above-stated plan for the construction of a network of subways with a total length of about 54 kilometers has been made based on the pattern of the built-up areas and taking into consideration the developing urbanization of the outer districts in the near future. Since the urbanization of Guadalajara is expected to continue in the future, it is desirable that the subways are so constructed that they can be extended in the future.

It is advisable to procure the land necessary for the expected subway line extensions at this time when urbanization has not yet progressed so much in the suburban districts. As for the structural type of the subway lines to be extended in the future, the elevated type would be economical because they will be running through the areas which are most liekly to be urbanized in the near future. In some case, however, it would be advisable to run the railways through open cut channel.

The extension plan is specially needed for Route No. 1 at its starting point situated in the southern part of the city, which is expected to spread farther to the southeast area due to the development of new housing projects and the increasing number of manufacturing establishments such as tobacco factory and Kodak factory. So, it will be necessary to extend this route about two kilometers in the future.

It will become necessary for Route No. 4 to be extended two kilometers or so because the southern district where the subway line will start is expected to be developed as a residential area in the future. It also will become necessary to extend this route from its terminal about three kilometers because urbanization including university laboratories and housing projects is expected to spread to the north.

Train depot construction plan:

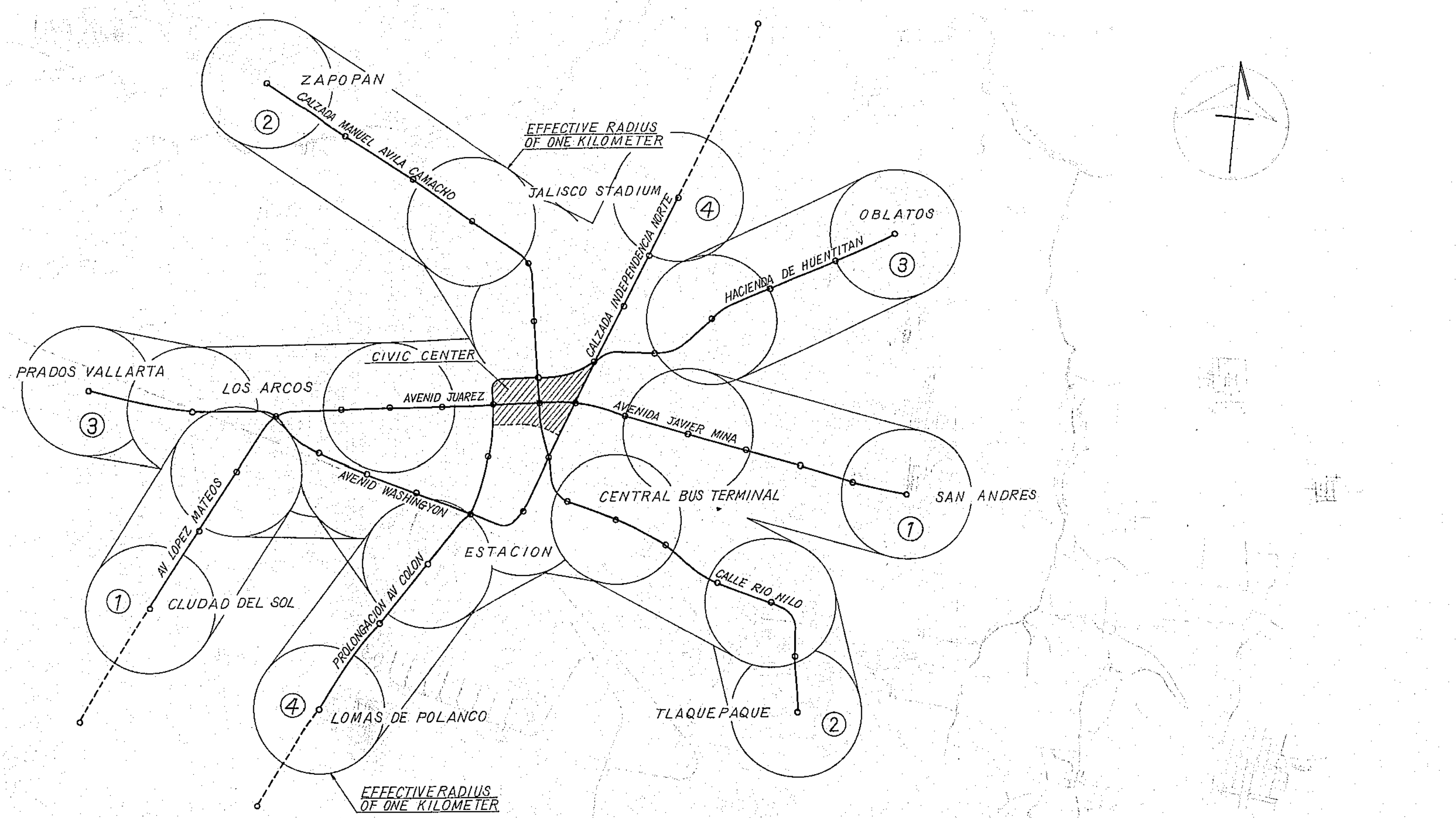
The sites of train depots for the subway routes have been determined, taking into consideration various factors such as the present and future land use plans, the degrees of difficulty in procuring land required for the construction of subway facilities, and the construction and operating plans to be discussed later.

Route No. 1 will have its train depot in the Ciudad del Sol area on the southwestern side, Route No. 2 will have one in the southeastern part of Zapopan, Route No. 3 will have one in the western Prados Vallarta area, and Route No. 4 will have one at Lomas de Polanco on the southern side. However, it is desirable to set up train depots on both ends of a route, if possible, from the standpoint of the train operating plan.

A train depot should be surrounded with a green belt 15 meters to 20 meters wide to protect the living conditions of the surrounding residential areas.

SUBWAY NETWORKS OF GUADALAJARA CITY

Fig 7—1



VERTICAL SECTION FOR EACH NETWORK

Fig 7—2

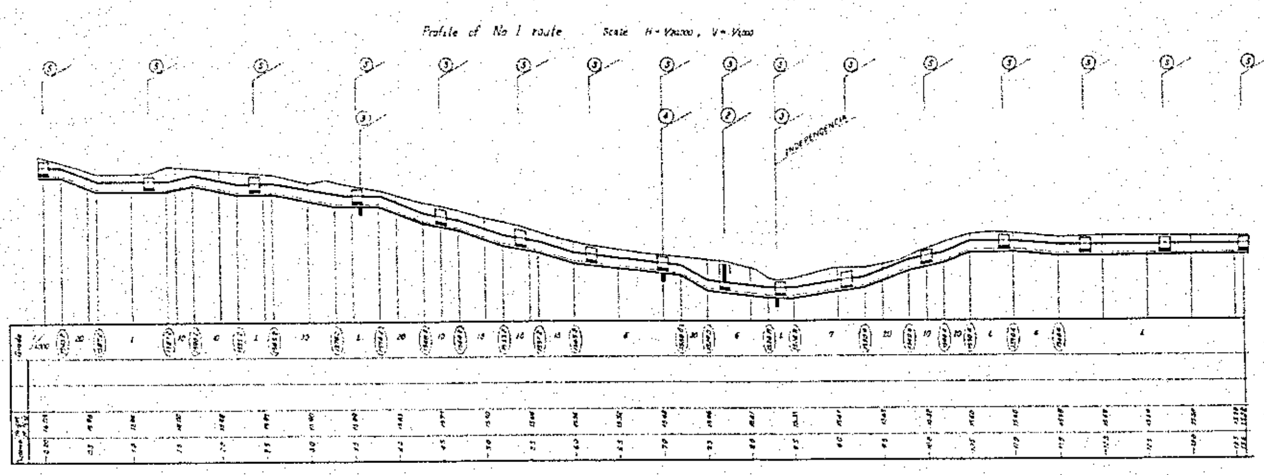


Fig 7—4

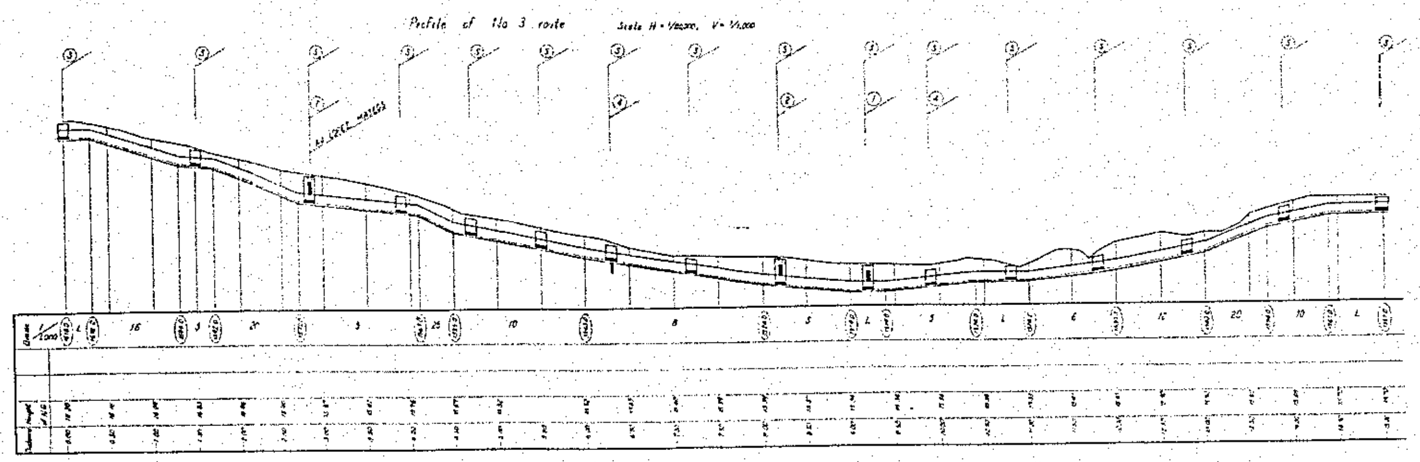


Fig 7—3

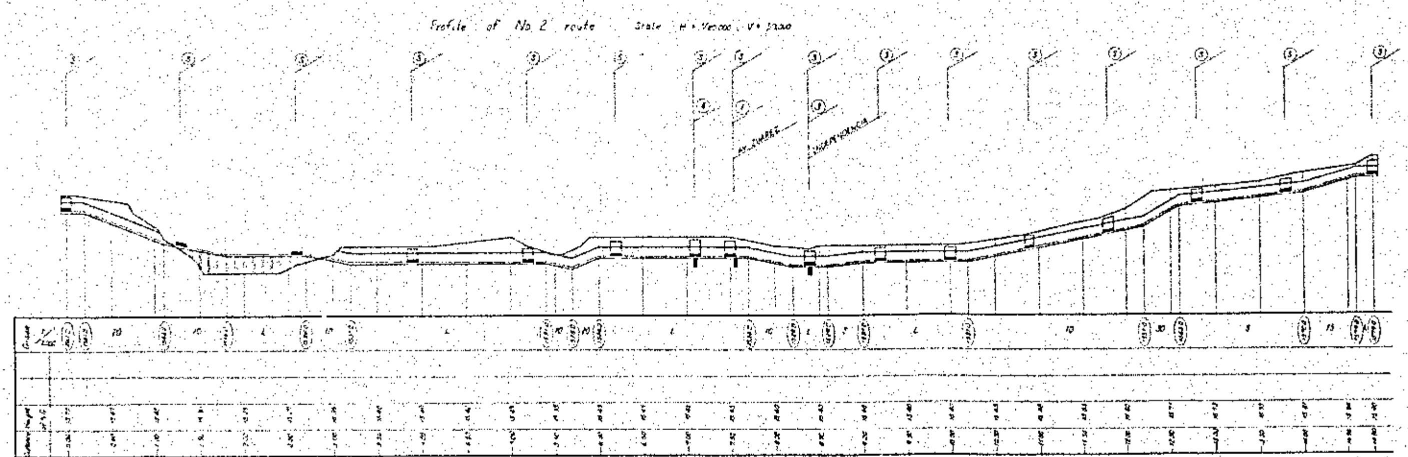


Fig 7—5

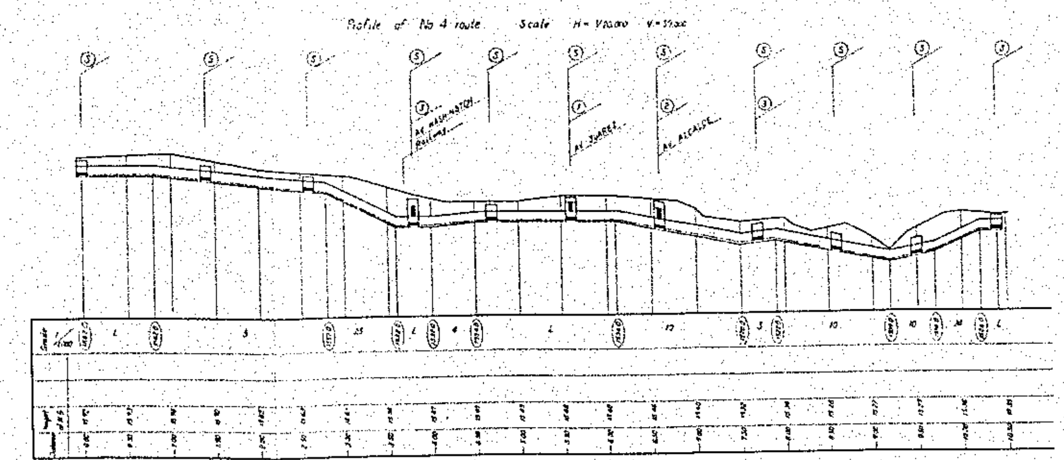


Table 7-1 Urban Transportation System in Guadalajara

Route No.	Route Length	Route's Main Points
Route 1	13.6 Kms. (15.6 Kms.)	Intersection: AV. LOPEZ MATEOS & Mariano Otero " AV. LOPEZ MATEOS & Av. Vallarta " AV. JUAREZ & Escobedo " AV. JUAREZ & Av. 16 de Septiembre " AV. JUAREZ & Calz. Independencia " AV. JAVIER MINA & San Jacinto (SAN ANDRES)
Route 2	14.8 Kms.	CALZ. MANUEL AVILA CAMACHO Intersection: AV. ALCALDE & Juan Manuel AV. 16 DE SEPTIEMBRE & Av. Juarez AV. CORONA & Calz. Independencia CALZ. 5 DE FEBRERO & 5 de Mayo PROGRESO & Capacha (TLAQUEPAQUE)
Route 3	15.0 "	CARRETERA A NOGALES Intersection: AV. LOPEZ MATEOS & Av. Vallarta " CIRCUNVALACION STA. EDUWIGES & Colon " CALZ. INDEPENDENCIA SUR & Av. del Campecino " CALZ. INDEPENDENCIA SUR & Av. Corona " CALZ. INDEPENDENCIA & Av. Juarez " CALZ. INDEPENDENCIA NORTE & Pablo Gutierrez " HACIENDA DE HUENTITAN & Av. Hda. de Oblatos
Route 4	10.4 " (15.4 ")	PROLONGACION AV. COLON (LOMAS DE POLANCO) Intersection: AV. COLON & Circunvalacion Sta. Eduwiges " ESCOBEDO & Av. Juarez " AV. ALCALDE & Juan Manuel " CALZ. INDEPENDENCIA NORTE & Pablo Gutierrez (Parque Morelos) " CALZ. INDEPENDENCIA NORTE (JALISCO STADIUM AND BULL FIGHT RING)
T o t a l	53.8 Kms. (60.8 ")	

Figures in ( ) are future prolongated lengths.

Extensions: Route 4 — Prol. to south 2.00 Kms. Route 1 – Prol. to south 2.00 Kms.
— Prol to north 3.00 Kms.

CHAPTER VIII. ESTIMATED VOLUME OF RAILWAY TRAFFIC

1. Estimated distribution of residential areas in the future

We estimated that the population within the urban traffic zone of Guadalajara will be some 3,500,000 in 1980. The distribution of residential areas of various types is supposed to be as follows.

Generally, the present pattern of the distribution of residential districts of various classes will remain unchanged and will continue to spread in various directions toward the suburbs.

So it is presumed that the eastern part of the city will develop as middle-class or densely populated ordinary class residential districts, the southern and southeastern parts as densely populated ordinary-class residential districts, the nothern and the northeastern parts as middle-class or densely populated ordinary class residential districts, the nothewestern part as middle-class residential districts (middle-class or densely populated ordinary class residential districts in the Zapopan area), the western part as upper-class or middle-class residential districts, and the southwestern part as middle-class residential districts.

These residential districts will presumably spread beyond the boundaries of this city into the suburban areas and will be expanded to cover a vast area of about 7 to 10 kilometers radius from the center of the city in 1980 and still continue to spread out at the same rate for the foreseeable future.

2. Estimated traffic volume in the future

We were not able to obtain data relating to the ratio of use of transport facilities per person and the Guadalajara City. So, the mission had to estimate from the data we had gathered, such as the volume of passenger traffic carried by buses, numbers of privately owned cars and taxicabs in operation in the city and also the state of things in Mexico City and some foreign cities.

The living habits and income standard of the people of this city are rising to about the same level of the inhabitants of Mexico City. In Mexico City the average number of trips per person is 1.4 a day and it is estimated to increase to 1.5 a day in the future. This figure is considered to be reasonable compared with other cities of the world. This is probably the same with Guadalajara and its passenger traffic is estimated to be about 1,960,000 persons as of 1968.

Of the total passenger traffic, about 1,300,000 or 66 per cent are now being carried by buses.

Judging from the estimated population of this city in the future, the total passenger traffic will presumably increase to about 5,300,000 in 1980 or 12 years from now.

In 1968 there was one privately owned car for every 32 person in Guadalajara City and 1980 will see about 50 per cent increase so that there will be one car for every 20 persons. In consideration of the population growth, the number of registered privately owned cars will be about 380 per cent of the present number. So, if the traffic situation is left as it is, the passenger traffic carried by privately owned cars and taxicabs will increase to about 2,500,000 persons a day in the near future.

The city is presently vigorously pushing on the road expansion plan, which is expected to be completed to a great extent in 10 years. However, there are limits to the road improvement in the midtown areas. So, it is necessary to give appropriate administrative guidance so that the passenger traffic now being carried by automobiles may be shifted as much as possible to mass transport systems such as subways and buses. One of the methods for this is that those who go to work in the midtown areas leave their cars at a subway station nearest to their suburban homes and the cars are left in the parking place or driven back home by their families. (This method called the "park-and-ride" or "kiss-and-ride" system is now being in use in U.S.A.) It will not impossible by this method to decrease the number of privately owned car traffic between the midtown section and suburban residential districts during the rush hours and reduce the vehicular traffic to about two-thirds of the previously given figure. Even with this method being employed, the volume of private car traffic in 1980 is estimated to increase to about 250 per cent of the present one and the number of passengers carried by private cars will be about 1,650,000.

Since it is necessary that buses take over part of the passenger traffic carried by privately owned cars, if the bus transport capacity is increased to 150 per cent of the present capacity, the buses will be carrying about 1,950,000 passengers in 1980.

From the above figures, the subways' share of passenger traffic will be as follows.

5,300,000–(1,950,000+1,650,000) = 1,700,000 (persons)

This being so, the percentage ratios of passenger traffic carried by different types of transport systems in 1968 and 1980 are as shown in Fig. 8 – 1.

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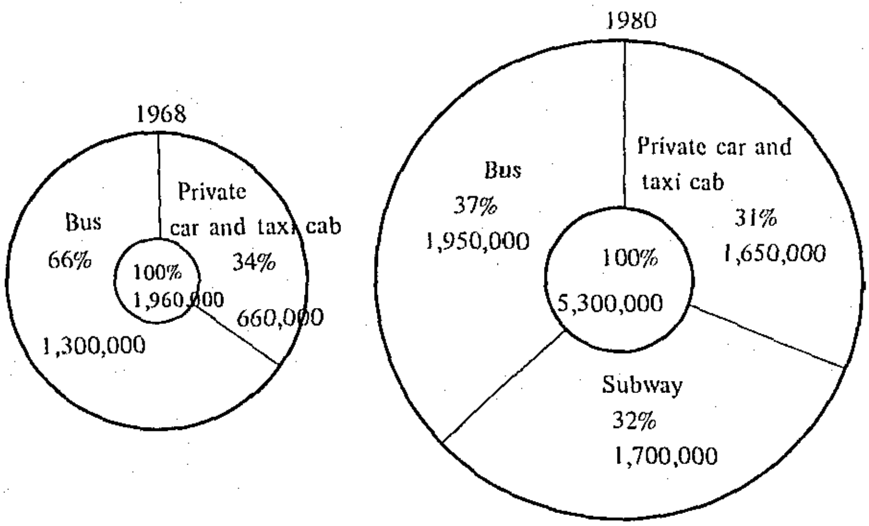
Fig. 8-1 Percentage ratios of passenger traffic carried by different types of transport systems



3. ***Estimated population in the range of use of the subway system***

The mission estimated the population within the range of use of the proposed subway network, using the estimated values of future population and by the following standards.

(1) The range of use of each subway route was divided into the primary range and the secondary range according to the distances from the railway line. The primary range is a region of 500 meters radius from the station. The secondary range is a region within one kilometer from the railway route on both sides, not including the primary range.

The time required for the passenger to reach the station from his or her home is 7 minutes or less in the primary range and 15 minutes or less in the secondary range.

(2) Each route of the proposed subway system will be running along the existing main roads and therefore the average population within the range of use of the subway is higher than in other parts of the region. Taking this into consideration, the population density, classified by type of residential district, is estimated as follows.

High-class residential district .... 15,000 persons per square kilometer
Middle-class residential district .... 20,000 persons per square kilometer
Ordinary residential district .... 25,000 persons per square kilometer

(3) When the ranges of use of two subway routes overlap each other, the population within the overlapping area is split between the two routes.

Following the above rule, the population within the primary and secondary ranges of use of the proposed routes of subways can be computed as follows.

Route No. 1
(15,000 persons x 3 km + 20,000 persons x 5 km + 25,000 persons x 5.6 km) x 2 = 570,000 persons
Route No. 2
(15,000 persons x 2.5 km + 20,000 persons x 5 km + 25,000 persons x 7.3 km) x 2 = 640,000 persons
Route No. 3
(15,000 persons x 6 km + 20,000 persons x 55km + 25,000 persons x 4 km) x2 = 580,000 persons
Route No. 4
(20,000 persons x 3.5 km + 25,000 x 6.9 km) x 2 = 490,000 persons

Total population within the range of use of all subway stations .... 2,280,000 persons

4. **Estimated numbers of users of the proposed subway routes**

Supposed that the rate of use of the proposed subway system is 0.6 for the primary range of use, 0.3 for the secondary range and the average rate for the total range is 0.42, the passenger traffic to be carried by each subway route can be computed from the area of the two ranges and the following estimated values are obtained.

(The average number of trips per person is supposed to be 1.5 a day.)
Route No. 1
570,000 x 1.5 x 0.42 = 359,000 persons per day
Route No. 2
640,000 x 1.5 x 0.42 = 403,000 persons per day
Route No. 3
580,000 x 1.5 x 0.42 = 365,000 persons per day
Route No. 4
490,000 x 1.5 x 0.42 = 309,000 persons per day

The number of private car users living outside the range of use of subways who are expected to switch over to the subways will be as follows.

$$(2{,}500{,}000 - 1{,}650{,}000) \times \frac{3{,}500{,}000 - 2{,}280{,}000}{3{,}500{,}000} = 300{,}000 \text{ persons per day}$$

Total passenger traffic carried bv the subways
1,440,000 + 300,000 = 1,740,000 persons per day

The total volume of passenger traffic to be carried by the whole subway system is estimated at 1,740,000 persons per day as given above. However, since the subway network is so designed as to be convenient for the passenger to change from one route to another, each route will carry such passengers transfering from other routes. So, the actual volume of passenger traffic to be carried by each route can be computed by supposing that 110 per cent of the number of passengers within its own range of use is the actual volume of passenger traffic the route will carry a day. Thus, the number of passengers each route is estimated to be carrying in 1980 is as follows.

Route No. 1

$$(359{,}000 + 300{,}000 \times \frac{359}{1{,}440}) \times 1.1 = 477{,}000 \text{ persons per day}$$

Route No. 2

$$(407{,}000 + 300{,}000 \times \frac{407}{1{,}440}) \times 1.1 = 540{,}000 \text{ persons per day}$$

Route No. 3

$$(365{,}000 + 300{,}000 \times \frac{365}{1{,}440}) \times 1.1 = 484{,}000 \text{ persons per day}$$

Route No. 4

$$(309{,}000 + 300{,}000 \times \frac{309}{1{,}440}) \times 1.1 = 413{,}000 \text{ persons per day}$$

CHAPTER IX. OPERATING PLAN

The size of transporting unit (number of passengers per car and the number of cars), number of transporting runs (operation intervals) and the speed of the train are the factors in making out the schedules of train operation.

1. Size of transporting unit

The size of a car will, if assumed to be 2.8 m wide and 18 m long as mentioned later, provide a capacity of 150 passengers per car in standard. The number of cars of one subway train is four to ten in Japan. The rout congested with passengers requires 10 cars, whose length is considered to be the maximum practically. A train composed of 6 – 8 cars may be most expedient. As the volume of transport differs according to sections on a line, it may be considered reasonable to reduce the number of cars at suburban sections where traffic volume is small. However, in case of short lines like those of urban express railways the same formation is adopted throughout all sections on a line, and cars are not disjoined or rejoined there.

As for the subway of Guadalajara City, 6-car formation, as practised in Tokyo, is deemed most suitable in view of the number of users. Transport capacity of such formation is: 16 x 6 = 900. Some two times of the above number can be accommodated, if congestion is allowable to some extent. Such train can transport some 2,000 passengers.

2. Time intervals for operation

The operation of urban express trains is always desired to be scheduled with as short intervals as possible.

It is possible to reduce the operation interval to 1 minute 30 seconds which, however, is usally 2 minutes for practical purpose because of reasons in relation to the distance between stations the distance between signals, number of passengers getting on and off at stations (stopping minutes required to take care of passengers at stations). A system of 2 minutes and 30 seconds interval is mostly adopted in Tokyo at present, with some exception of 2 minutes.

On the other hand, the urban express railways are required to be operated with intervals less than 10 minutes even in daytime hours for the convenience of users to make them available without waiting so long.

The operation intervals are calculated as follows on the bais of estimated traffic volume classified by route obtained as stated in the preceding chapter.

The factor that determines the minimum interval required is the traffic volume between the most congested sections during the rush hours.

The most congested sections are the commuting lines toward the city center, and the volume of such transport is estimated at 90% of all in the light of examples in many cities and taking into consideration the suburban-bound transport from the city center during the same hours.

The rate of transport volume during the most busy one hour to that of a whole day (concentration rate) is 8.2% in the case of Mexico City. This rate tends to rise with the development of cities. This is within the range from 10 to 15% for Tokyo.

Accordingly, it is planned with the concentration rate (per hour) of 10% here.

Table 9–1 shows the planned maximum transport capacity, and the shortest operation intervals in this city.

3. Operating speed and running time

The exact figures of the train speed and the running time should be determined on the basis of the operation curve made from the conditions of the railway tracks (vertical gradient and radius of curve and the like) and the vehicular performance curve. Approximate figures calculated from the past experiences are shown in Table 9–2.

Table 9-1 Planned maximum transport capacity and shortest operation intervals

Route	Total traffic volume per day	Volume of traffic in one direction per day	Traffic volume passing the most congested sections	Traffic volume per hour during rush hours (one-way)	Planned transport capacity and riding efficiency	Shortest operation intervals: Number of trains operated per hour
	Unit: 1000	Unit: 1000	Unit: 1000	Unit: 1	Unit: 1	
No. 1	477	239	215	22,000	21,600 102%	2 m 30 s 24 trains
No. 2	540	270	243	24,000	21,600 110%	2 m 30 s 24 trains
No. 3	484	242	218	22,000	21,600 102%	2 m 30 s 24 trains
No. 4	413	207	186	19,000	21,600 88%	2 m 30 s 24 trains
Total	1,914			87,000	86,400	

Table 9-2 Operating speed and running time of each route of Subway

Items	Route No. 1	Route No. 2	Route No. 3	Route No. 4
Length of line	13.6 km	14.8 km	15.0 km	10.4 km
No. of stations (both terminals included)	16	16	16	16
Junction stations	4	3	5	4
Others	12	13	11	7
Average distance between stations	0.91 km	0.99 km	1.00 km	1.04 km
Total minutes for arrival	27 m	30 m	30 m	21 m
Scheduled speed	30 km/h	30 km/h	30 km/h	30 km/h
Maximum speed	80 km/h	80 km/h	80 km/h	80 km/h

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The train must be speed up as much as possible in order to make all other factors advantageous. In this case where the distance between stations is 700 m at the central area and 1 km – 1.2 km at suburban areas, the optimum maximum pseed is calculated to be 80 km/h.

4. Train kilometers

The train kilometers for one rush hour are as shown below:

Route No. 1	13.6 km x 24 trains x 2 = 653 (train kilometers)	
Route No. 2	14.8 km x 24 trains x 2 = 710	
Route No. 3	15.0 km x 24 trains x 2 = 720	
Route No. 4	10.4 km x 24 trains x 2 = 499	
Total	53.8 km	2,582 (train kilometers)

No exact figure can be calculated for the total train kilometer per day without the schedule made. The calculation is made roughly here to secure the transport capacity to meet the transport demand, taking into consideration the ratio of transport demand classified by time zone in Mexico City.

As stated in Item 5, paragraph 5, Chapter 2, the peak of the congested hours is in the afternoon in Guadalaraja City at present. It, however, is considered that the transport demand would come to be concentrated at the commuting hours both in the morning and evening as the city makes development. A daily schedule is made as shown in Table 9-3 under the above assumption and by reducing the transport capacity for the daytime, early morning and midnight.

5. Railway cars

Urban express railways, in which distance between stations is short, require high efficiency in vehicular performance of speed acceleration and deceleration. The following performances are desirable as vehicular standards.

Elements of railway car:

- Main dimensions: Length – 18.00 m; Width – 2.79 m; Height – 3.50 m
- Capacity: 150 passengers
- Dead load: 35 tons
- Main motor: 75 kw x 4
- Maximum operating speed: 100 km/h

- Brake device: Electromagnetic direct brake used with dynamic braking
- Accelaration: 4.0 km/h/s
- Deceleration: 4.0 km/h/s (ordinary); 5.0 km/h/s (emergency)

The required numbers of cars are as follows:

	Route No. 1	Route No. 2	Route No. 3	Route No. 4	Total
Total minutes required for arrival	27 m	30 m	30 m	21 m	
Operating intervals	2 m 30 s	2 m 30 s	2 m 30 s	2 m 30 s	
No. of operating trains required	25	27	28	20	100
No. of cars required	150	162	168	120	600
Spare cars for inspection and repairs	18	20	21	15	74
Total number of cars	168	182	189	135	674

Twelve per cent of the operating cars is set aside as spare for use in case of inspection and repairs. Accordingly, the total number of cars comes up to 674.

It is advisable to install, as a setup for inspection and repairs, service tracks and facilities around the either terminal of each line for inspection of cars alternately (inspection once a month) and a repair shop for all cars at the operation base of Route No. 1.

One repair shop could take care of more than 6,000 cars, enough for 674 cars and therefore should be so arranged as to meet the future requirements of expansion in response to increasing cars.

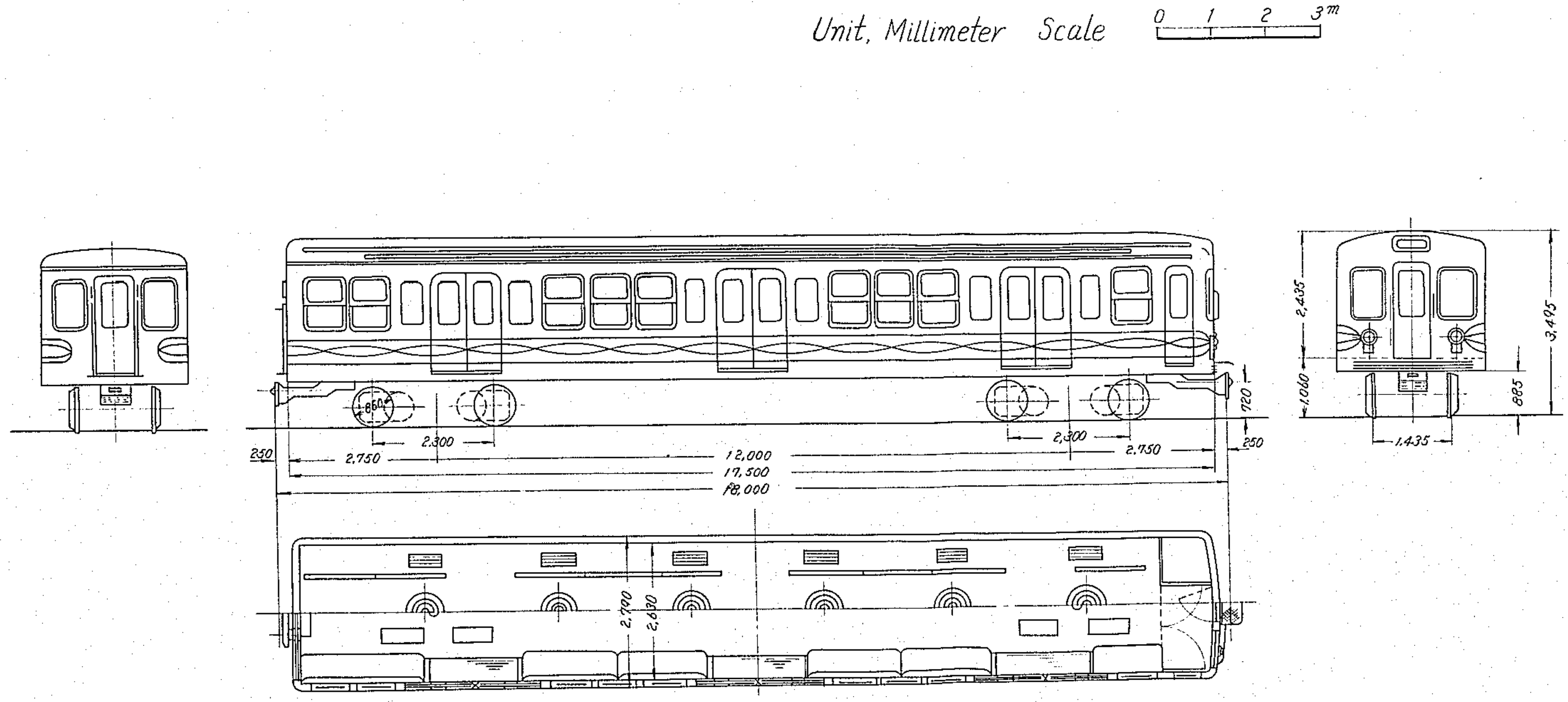
Table 9-3. Ratio of passengers transported classified by time zone and the train kilometers

Time zone	Ratio of passengers transported in Mexico City (%)	Ratio of passengers transported in central Tokyo (%)	No. of one-way trains per hour on a line, in Tokyo	Ratio of train kilo-meters, in Guadalajara City (%)	Train kilo-meters per hour, in Guadalajara City	No. of one-way trains per hour on a line in Guadalajara City
Hours						
4–5	2.5	2	3	12.5	323	3
5–6	11.3	6	9	25.0	646	6
6–7	47.5	11	13	50.0	1,291	12
7–8	100.0	48	23	100.0	2,582	24
8–9	92.5	100	24	83.3	2,152	20
9–10	87.5	56	24	62.5	1,614	15
10–11	83.0	30	14	62.5	1,614	15
11–12	81.0	20	12	50.0	1,291	12
12–1	90.5	21	12	50.0	1,291	12
1–2	79.0	24	12	50.0	1,291	12
2–3	85.0	22	12	50.0	1,291	12
3–4	82.0	26	14	50.0	1,291	12
4–5	92.5	39	16	62.5	1,614	15
5–6	97.5	85	18	75.0	1,937	18
6–7	99.0	69	17	62.5	1,614	15
7–8	91.5	43	15	50.0	1,291	12
8–9	60.0	34	14	45.8	1,184	11
9–10	35.8	29	12	41.6	1,076	10
10–11	21.4	15	10	25.0	646	6
11–12	18.8	12	6	16.7	430	4
12–1	10.0	4	3	12.5	323	3
Total			283		26,792	249

Fig 9—1

GENERAL VIEW OF CAR

Unit, Millimeter Scale



CHAPTER X. CONSTRUCTION GAUGES

1. Various gauges

1) Gauge drawings

Gauges for cars and buildings and dimensions for cross sections of constructions are decided as shown in Fig. 10-1.

2) Railway gauge

No railway tracks exist in Guadalajara City which presently require consideration for connecting, and accordingly the railway gauge can be determined from an independent standpoint. Therefore, we adopt the standard gauge of 1435 mm which is widely used internationally.

3) Electrical system

A third-rail system is adopted. The voltage of the motive power is 750 V., D.C. There are two devices for collecting electric current—aerial wire and the third rail. The use of aerial wire makes it necessary to raise the height of tunnel interior approximately by 1050 mm, even if a special device, called rigid wire support, is provided. This makes the cost of tunnel construction higher by 8%. The higher the voltage of the motive power, the more the electric installation cost can be reduced. In the case of the third-rail system, 750 V. is adopted here which is regarded the maximum possible voltage from the viewpoint of maintenance and safety of the maintenance staff members. Mostly 600 V., D.C. is used under the 3rd-rail system in Japan, while 750 V.D.C. is used in Osaka.

The aerial wire is used in some of subway lines in Tokyo and Kobe but this is because there are such compulsory conditions to meet the requirements for through operation by subway and suburban railway already in operation. However, the third-rail system should be adopted for the city like Guadalajara where the design can be made free from such restriction.

4) Gauge for railway car

The gauge for railway car shown in Fig. 10–1 indicates the limits in respect of maximum allowable dimension of a cross section of a car.

For larger transport capacity, a larger width of a car is required, which, however, makes it necessary to enlarge the ross section of tunnels, resulting in higher cost of tunnel construction. Under such conflicting conditions, 2800 mm is adopted as the width which may be capable of meeting the future requirements for increased traffic volume in Guadalajara City.

The gauge, in height, of a car is set at 3500 mm above the rail level. The height of a car body should be determined according to the physique of the public passengers. The height presently adopted in Japan is considered sufficient enough for the Mexicans.

5) Length of railway car

The length of a car is set at 18 m. In principle, a larger transport volume is obtainable by increasing the length of cars. This, however, necessitates enlargement of the cross section of curved tunnels and results in extending the clearance between the car body and side of the platform of the station, and also increassing the load over the bogies. Taking into account such disadvantages, 18 m is adopted for the length of a car.

For larger traffic volume, the scheduled speed of a train should be increased. In the case of urban railroads like subway, distance between stations is required to be shortened. The shortening of the stoppage time at stations, therefore, becomes an important factor in increasing the scheduled speed of the train. The space between doors must not be large in order to secure the quick getting on and off of passengers at stations. Accordinly, 4 doors are provided for the car body whose length is 20 m. This means the number of doors is more by one than that of the 18m – long body.

As the result, the capacity can not be proportionally increased. Thus, the lengthening of the car body does not always serve to increase the capacity of a train.

6) Construction gauges

The construction gauges shown in Fig. 10–1 indicate the limitation for the minimum allowable cross section dimension which must not be violated by the tunned structures or installation in the straight-line tunnels. The difference in gauge between construction and car of 200 mm and 300 mm respectively at the side and the top of the car is an allowance needed for the rocking of cars in operation, prevention of rise of the car at its center on the rail at the point of change in grade and for the performance of maintenance works on the tracks.

7) Size of tunnel cross section

To provide spaces for the wires of power, lighting and signals in tunnel and for a shelter at the central pillars for workers in tunnel, it is so designed as to give clearance between the construction gauge and the inside surface of tunnel, 300 mm at the side wall and 200 mm at the central pillars.

2. Design standards

1) Table of design standards

Design of lines is made according to Table 10–1.

Table 10-1. Design standards

		Standards	Remarks
Minimum radius of curvature	Main line	160 m	
	Line attached at the junction of main line	100 m	Radius of curvature at No. 8 junction is taken into consideration.
	Line along the platform	500 m	
Length of transition curve		When radius of curvature is smaller than 800 m, $L = 0.07\frac{V^3}{R}$ (m)	V: Velocity R: Radius of curvature V for R is provided separately.
Distance between transition curves in opposite directions		Longer than 15 m	If impossible, straight line is not interposed.
Cant		$C = 10\frac{V^2}{R}$ (mm) C: Cant (mm) V: Velocity (km/h) R: Radius (m)	No cant is provided where radius of curvature exceeds 800 m at the part along the platform. In case radius is less than 800m, cant is provided for the train speed, 20 km/h. Reduction in cant is made covering the straight length 300 times as long as the cant, where transition curve is not provided.
Maximum grade	Main line	35/1000	
	Within station	10/1000	
	Side Line	45/1000	Less than 3/1000 for side line where retention of car is required.
Minimum gr		2/1000	Not applicable to tracks along the platform
Minimum longitudinal curve radius		3000 m	Only when the plane curve radius is longer than 300m and when unavoidable, it can be made 2500m and 2000m respectively for the main line and side line.
Enlargement of construction gange by means of curve		$W: \frac{20,000}{R}$	W: Length to be extended on both sides (mm) R: Radius of curvature (m)
Slack		Where radius of curvature is smaller than 600m. $S = \frac{4500}{R} - 5$	S: Length to be extended toward inward of the curve (mm) R: Curve radius (m)
Space between R.L. and track bed bottom	Concrete bed	400mm	500mm, in case the radius of curvature is smaller than 200m.
	Ballast bed	800mm	The gravel ballast bed is used under houses or sections requireing protection from vibration.

Miniumu space between centers of tracks	Surface line, 3,400 m Underground line, 4,050 m	Standard space is 3.500m for surface line, regardless of straight or curved.

Notes:
(1) Increase of cant, slack and excess shall be reduced over the full length of the transition curve.
(2) The minimum radius of curvature indicates the radius of the inward track.
(3) Relation between R and V in the formula for cant and the length of transition curve:

R (m)	160	200	250	300	350	400	Over 530
V (km/h)	42	50	55	60	65	70	80

2) Minimum radius of curvature

Since the minimum radius of curvature is related closely to the train speed, it is desirable to make it 200 m at the smallest so as to keep the minimum speed to about 50 km/h. A larger radius of curvature results in increasing the area to be occupied under the private land at a place of small angled road intersection and the like. Therefore, the minimum curve radius is allowed to a limit of 160 m. A small curve radius had defects not only to restrict the train speed but to make maintenance of rails difficult because of heavy abrasions occurring on rails.

The minimum radius of curvature is limited to 500 m for rails along the platform so as to prevent a large clearance between the car body and the platform side.

For the line leading the train into the depot the minimum curve radius is allowed to be reduced to 100 m, as the speed is not required as in the case of the main line.

3) Transition curve

A transition curve should be placed where cars move from straight line to curved line or in reverse case so as to insure consecutive and uniform changes in centrifugal force by changing the radius of curvature consecutively and smoothly from infinity to the radius of curvature at the place or vice versa so that a smoth operation can be secured.

The length of the transition curve is determined on the basis of the change rate of cant per unit time or the change rate of centrifugal force per unit time or a fixed magnification of speed reduction in consideration of safety against derailment when a car is supported at three points.

The length as provided for in Table 10–1 will satisfy all the conditions.

4) Cant

Centrifugal force is produced when the train passes on a curved line and this differs according to the train speed and the radius of curvature. The outside rail on the curved line is raised to provide against the said contrifugal force. This is called cant. There is a fear of overturn when the train stops on a curved line, if too large cant is provided. The maximum height of cant shall be so determined that the center of gravity of the train does not exceed the middle third of the gauge length, when the train stops on a curved line. Taking into consideration the allowance for the warp in the gauge and effects of deflection in car springs, the limit of V for R is determined as shown in the notes of Table 10–1.

5) Grade

The limits for the maximum grade differ according to the performance of cars. The cars to be used in the subway usually have a superior performance as compared with those of surface trains, and therefore it is possible to adopt a large grade.

In case a tunnel is constructed by means of cut and cover method the depth of excavation affects greatly the construction cost. A steep grade is required at the subway intersections or at places of transfer from underground to the elevated railway.

To provide for accurate stoppage and for an allowance for the pulling power at the starting time, a small grade is given along the at the station platforms.

A larger grade may be applicable for lines leading in and out of the car depot. In order to prevent any uncontrollable run of cars, the grade must be small for lines in the depot or for retention lines where cars must be retained.

Minimum grade is required for a drainage in tunnel.

(6) Oversize of construction gauge and track gauge at a curve

Oversize of construction gauge at a curve indicates that the front edge and the central part of the car body go horizontally beyond the construction gauge provided for the straight line, as shown as Ec and Ee in the following Fig.

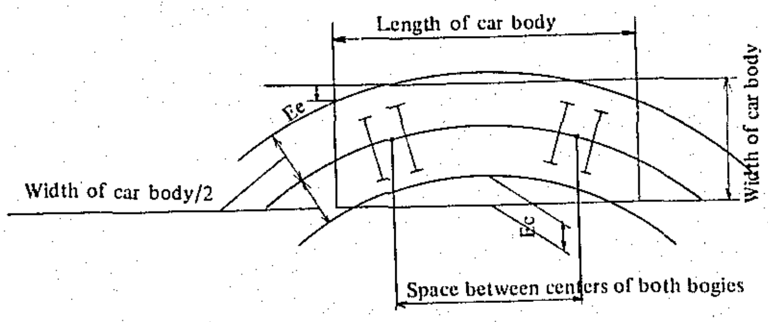


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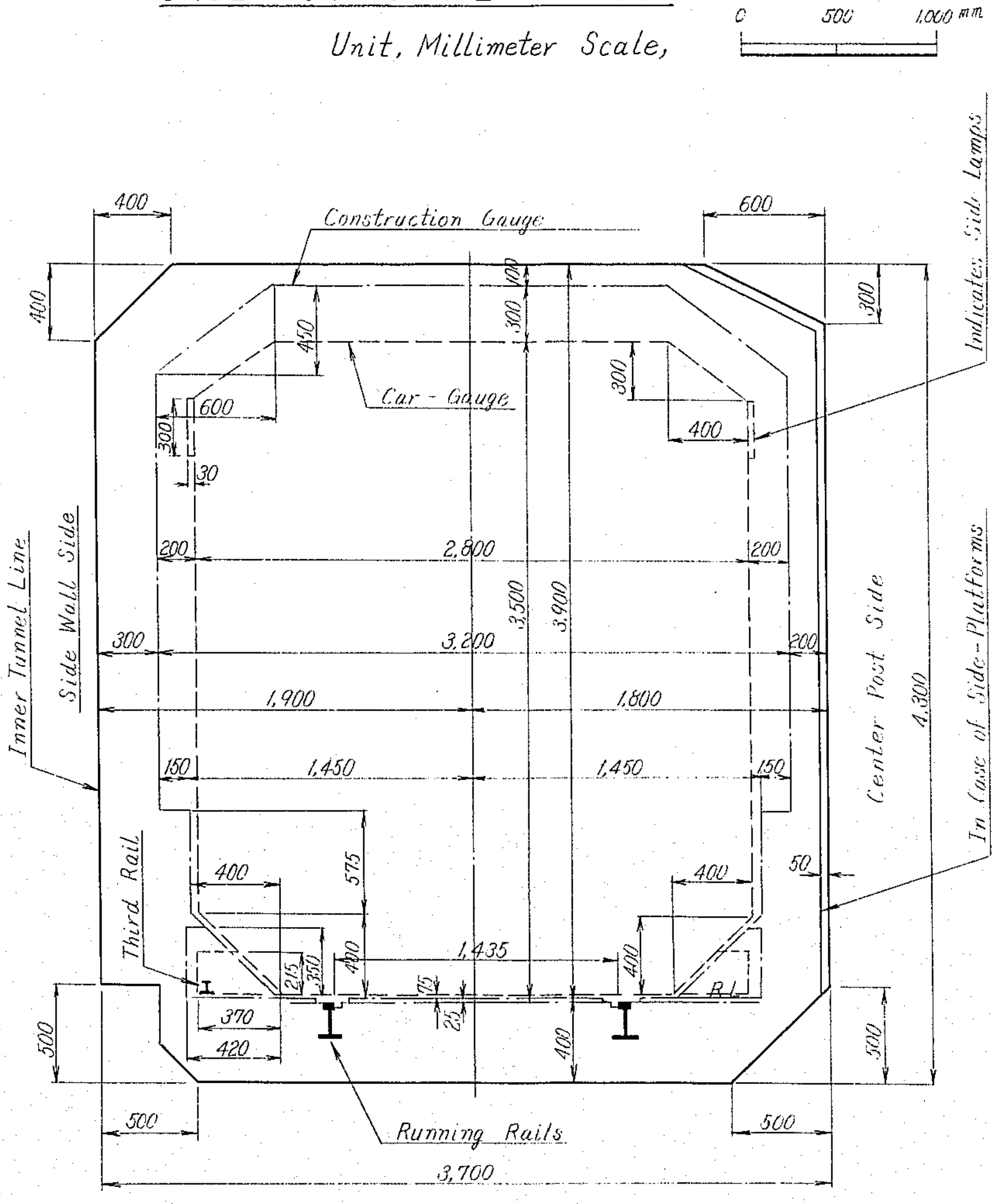
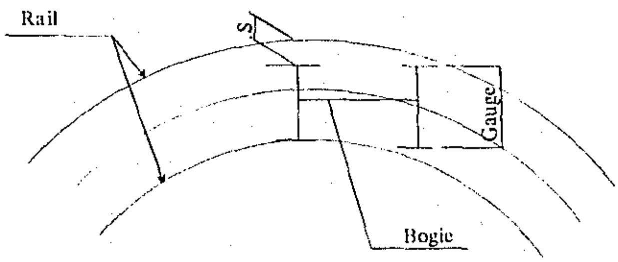
Fig 10—1

GAGE FOR TUNNEL AND CAR

Unit, Millimeter Scale,



Slack means enlargement of space between rails aimed to make smooth the run on curve, as the two axles of bogies are fixed in parallel. It is shown as S in the following Fig.



CHAPTER XI DESIGN AND EXECUTION OF CONSTRUCTION

1. **Design of tunnel**

1) Type of tunnel construction

The cross section of a tunnel consists of square, arch and round shapes. The round shape is adopted as the cross section of tunnel built by the shield method, but its space availability is the worst for square type car body.

The arch shape was developed by the techniques used in constructing large masonries. This cross section is adopted in the subway and the tunnel for drainage. Construction of a tunnel of arch shape is classified into two types, one being equipped with vertical side walls while the other without for the most part. The former type is used where the earth has sufficient depth over the tunnel by putting an arch into the upper slab of the square shaped cross section. The latter is prevalent in Paris, etc., as a pillar-less structure adopted in stations of island type platform which requires a large cross section. The arch shape, when used in a cross section with a large span, contributes much to the lessening of thickness of the upper and lower slabs. If used at stations, the ceiling can be elevated at its center. This adds much to the grandeur of the appearance. However, the larger the span, the worse the space availability, and the natural ventilating efficiency by the piston action of the train is reduced. Attention should be paid to the above facts. Temperature rose due to insufficient ventilation in an arch shaped tunnel for a two-track line recently completed in Montreal, Canada. This made it imperative to provide additional sturcture of vertical shafts for ventilation between stations.

The square-shaped cross section is most suited for the square-shaped car body. This affords the highest utility of space in a tunnel, and makes minimum the use of underground area. With its little clearance between the car body and the internal surface of the tunnel, natural ventilation is easily performed by the piston action of the train.

Conceivable as materials of construction are stone, concrete, reinforced concrete, PS concrete and steel. In view of the facts that this is an underground construction, considerably large cross section is required, work is often restricted as it is executed under the busy streets, and the design has to be changed often during the execution of work, the reinforced concrete structure is deemed most fitted. However, design should be so made as to utilize the characteristics of other materials to suit the pillars of the station, beams required of long span and other special places.

In order to minimize the cross section area and lessen rationally the thickness of the tunnel wall, flat-slab rigid frame construction is advisable for the square-shaped cross section. Putting these data together, it is concluded that the tunnel construction by cut and cover method should be of reinforced concrete of flat-slab and box-type rigid frame type. A standard cross section is shown in Fig. 11-1.

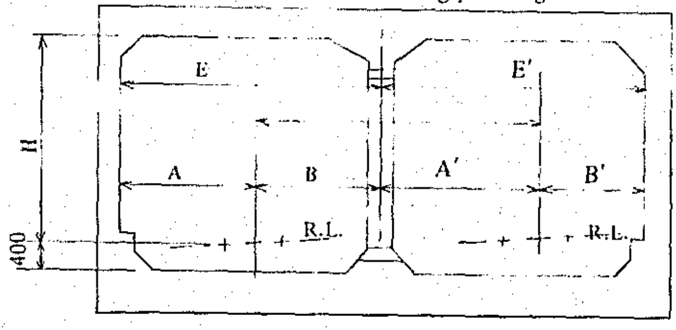
However, at the northern part of the city where the rook formation is found near the surface of ground, blasting is required for excavation. Blasting was seen at a work site for a drainage tunnel, but generally the use of dynamite must be avoided in the city area. For the excavation required for a tunnel in such area, it must be planned to apply the horizontal cutting process as in case of mountainous terrain.

In this case, the tunnel should be made of reinforced concrete or plain concrete, and a system of two parallel tunnels for 2 single-track lines is a standard type as shown in Fig. 11-2. The sturcture of elevated railway need by a geographical reasons at a portion of Route No. 2 should be an elevated slab-beam construction of 3 continuous spans, with foundation piles of reinforced concrete placed at site, one each under a pillar.

2) Enlargement of tunnel cross section at a curve

The cross section of tunnel must be enlarged in accordance with the radius of curve at the curved section. The method of calculation on the unit of m.m. is as follows;

When the center of curve is on the left side of the following plane figure:



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$$A = \frac{\text{width of construction gauge} + (\text{allowance to the side wall}) + \alpha}{2}$$

$$= 1600 + 300 + \alpha$$

$$B = \frac{\text{width of construction gauge} + (\text{allowance to the central pillar})}{2}$$

$$+ \frac{\text{width of central pillar}}{2} + \beta = 1600 + 200 + 225 + \beta$$

$$A' = \frac{\text{width of construction gauge} + (\text{allowance to the central pillar})}{2}$$

$$\frac{\text{with of central pillar}}{2} + \alpha = 1600 + 200 + 225 + \alpha$$

$$B' = \frac{\text{width of construction guage} + (\text{allowance to the side wall surface})}{2}$$

$$+ \beta = 1600 + 300 + \beta$$

$H = 3800 + 100 + h$

Where h is an increased height by cant

$\alpha = W + qc + s$

Where α is total increase inside the curve

$W = \frac{20,000}{R}$: Expansion of construction limits resulting from curvature

qc: Inferior excess product by cant

$S = \frac{4500}{R} - 5$: Slack

$\beta = w - qc$: total increase outside the curve

$w = \frac{20000}{R}$

qc: Outside excess produced by cant

By taking expanded dimensions of above figures the following formula is obtained:

$E = A + B = A' + B' = E'$

Thus the left and right side cross section of a tunnel can be made in contrast.

3) Designing for loads

The subway lines are generally projected under roads and the loads which require consideration are load of traffic and of earth onto the upper slab, earth pressure, taking into account the underground water, to the side walls, and the subgrade reaction to the lower slab. In the proximity of buildings, the effects therefrom must be taken into consideration. For the lines passing under the private land, it should be so designed as to stand the load on the subway tunnel of the buildings (present and future) which should be borne by the foundation. In the case of land on which possibilities exist for construction of buildings in the future, a tunnel of a type to be built under houses and which is capable of bearing the foundation for a reinforced-concerete 4-story building must be constructed. Compensation to the land owner for the restriction of buildings could be solved on this condition. In this case, the subway tunnel must be designed to be strong enough to stand the load of the foundation for the building, and at the same time, a prior survey should be made to check if the earth beneath the subway tunnel can stand the load of the building too.

Generally, the underground constructions are less subject to the effects of earthquake, and there is no record of heavy earthquake in Guadalajara City. Therefore, no special consideration is required for the load at the time of earthquake. As for the loads on the elevated constructions on the ground, the same principle as in case of general buildings may be applied.

4) Water proof layer

The perimeter of the subway tunnel is in principle enclosed with water proof layers of asphalt composed of hessian cloth and felt in the 2nd or 3rd layer. Since the cost and term of this work are related closely to the construction of the tunnel, the underground water level, the coefficient of the permeability of the underground water, existence or non-existence of underground water pressure should be made known prior to the construction work by geological survey. The water-proof layers may be omitted if circumstances permits.

The underground water lavel is about 6m at the center part of Guadalajara City. At the site of drainage work, excavation as deep as 5m is often practised without timbering there. In sight of this, the underground water is not considered to give harm to the execution of the work, and the leakage of water after completion of work can be fully disposed of by the draining capacity of the pumping rooms installed within every 2 km in full length of the tunnel.

5) Structure of railroad track

The facts, that the subway tracks run underground and the number of runs of train is large, make the following conditions imperative.

(1) Number of runs of trains is large and the maintenance work is almost imopossible to perform while in operation, and therefore high durability is required.

(2) Because of short period of no-operation, it must be so constructed as to insure speedy maintenance job.

(3) Less vibration and noise.

(4) Structure to make the cross section of the tunnel as small as possible.

(5) Structure against small curve radius and steep grade adopted at many places.

In view of the above conditions, concrete bed should be used in the tracks as shown in Fig. 11-4. The ballast bed in the tunnel under buildings however should be so designed as to prevent noise and vibration. The concrete bed should be equipped with an elastic fastening device which connects the bed and rail through rubber material. The rail should be that of 50kg/m, and case-hardened rail, superior in resistance against abrasion, is used at curves. The frogs made of manganese steel should be used. Rails should be connected by means of welding, and the number of joints be made as few as possible to lighten the maintenance works, prevent noises and for the comfort of passengers.

6) Drainage system

Water to be pumped out from the tunnel includes water used at stations, rainwater from ventilation openings and entrances and the leakage in the tunnel. Such water is collected in the trap basin equipped on the concrete bed, and from there it runs down along the longitudinal grade of the tunnel, then collected in the trap basin in the pump rooms and pumped out into the drain.

The size of the pump room and the distance between rooms are dtermined according to the atmospheric condition of the place, state of underground water and the installation of stations. For the subway of this city, it is considered sufficient c each having to 5 inch-pumps. In principle, the pump rooms are placed at sunken points in the longitudinal grade. Where to place the pump rooms should be a consideration to made in determining the longitudinal grade.

The structure of a pump room includes side room (see Fig. 11-5) and under room (see Fig. 11-6) types. The basin for the former is placed sideways of the tunnel and under for the latter. The side room type should be the standard unless otherwise restricted in terms of land required.

2. Railway stations and train depots

1) Scale of railway station

The construction for the tunnel for a part of a station costs three times as much as that for a two-track line per meter in average. Consequently, the scale of the station is a very important factor that weights heavy with the construction cost for the tunnel as a whole. However to widen the tunnel for the station facilities in the future is a very difficult work, or almost impossible. The scale of stations, therefore, must be prudently decided through thorough survey.

2) Type of platform

There are two types of platfororm, one being a separate formation having two-track lines between two platforms and the other an island formation with a platform separating the two-track lines. Merits and demerit are plainly shown in Table 11-1.

Table II-1. Types of platform

Items compared	Separate type	Island type
1 Alignment of tracks	Good	Inferior, requires reverse curve
2 Requirement of entresol	Not always necessary	Necessary, in principle
3 Depth of structure	Shallow	Deep
4 Utility of space in construction	Good	Inferior, unavailable space at junction in front and in the rear of station
5 Utility of underground area	Low	Better utilized for entresol
6 Construction cost	Lower	Higher
7 Platform extension work	Possible	Almost impossible
8 Utility of platform	Lower	Higher
9 No. of ticket window & wicket & operating cost	Separated to both sides, operation costs higher	Concentrated at a place, operation costs lower
10 Getting on & off, convenience for transferring passengers	Inferior	Good

Generally, the separate type seems advantageous. However, in view of the effective availability at rush hours of the width of the plarform of the busy stations at the central area of the city, convenience for passengers to get on and off and transfer, and effective use of the underground area, island type should be adopted for the stations above mentioned and the junction stations where two lines intersecte each with the other. The separate formation is a standard for other stations.

3) Length and width of platform

The length of platform is determined according to the length of the longest train with some allowance needed for operating techniques. Where the 6-car formation makes the longest length of the train, 6 x 18m = 108m is obtained. The allowance is given 5m respectively in front and in the rear. Then the length of platform is obtained as follows: 108 + 5 x 2 = 118m

The width of a platform should be determined on the basis of the number of passengers, present and future. The standard width recommended for this city is 4.0m for the separate type and 8.0m for the island type platform. Further studies be made to widen the width of important stations like those where Route No. 1 and No. 2 are crossing. The minimum available width should be 3.5m for the separate type and 7.0m for the island type.

4) Standard type of platform

There are following standard types of stations; island type with entresol as shown in Fig. 11-7; separate formation with entresol as shown in Fig. 11-8; separate formation without entresol as shown in Fig. 11-9. For the type as shown in Fig. 11-9, a passage must be made under the tunnel to connect both platforms. Fig. 11-10 is a general picture of a junction station to be constructed at the center of the city.

It is desired that the platform at lower level be equipped with an escalator. For an effective use of the platform area, Dactyl-steel tube is preferable as the material of pillars on the platform so as to lessenthe area occupied.

5) Railway station facilities

Facilities needed in railroad stations include the follwoing:

(1) Booking office: Passenger fares will be a flat rate of token system. The booking job will be performed mainly by the automatic machine, and the window is required only for money exchanging job. The automatic vending machine should be placed with its back side within the booking office for the convenience of maintenance and inspection.

(2) Wicket: A machine will be used to permit automatically a single person pass through when the token is put in. The machine will be placed where it can be watched out from the booking office.

(3) Facilities for station business: Facilities required for the performance of station duties are: an office, a rest room, a lodging room, an assembly room, latrins for station workers, a warehouse and a water boiling room. The office and assembly room are not always needed in every station.

(4) Electrical facilities: Necessary facilities are an electrical service room to receive the high-volt distribution lines, a terminal board room and a battery room to secure the source for the minimum required electricity for safety at the time of service interruption.

(5) Passengers latrine: Installation of a latrine for passengers at every station will increase the expenses both in construction and maintenance costs. It is desirable to install a latrine, however small, at every station in conformity to the number of passenger.

6) Passage to and from the ground

Places suited for installation of entrance are the greens of a plaza, sidewalk, and a private land facing the road.

The entrance to the subway, when installed on the greens of a plaza, will make it easier for the passenger to locate. Its place should be selected taking into consideration the convenience for the transfer to the bus or taxi and the relative location of pedestrians' crossing. The outward appearance must so made as to suit the green zone.

The entrance installed on the sidewalk is most convenient for the passengers. This, however, will result in obstructing the pedestrians, if the sidewalk is not wide enough. In Tokyo such entrance is not provided unless the sidewalk is wider than 5m. The minimum width of the entrance is 1.5m.

In installing the entrance within the private land, such land should be faced with road under which the subway runs, some conspicuous signs should be provided to indicate the location of the entrance. The land under which the subway runs is generally a valuable place. Accordingly, the land should be utilized in a most efficient way, such as for erecting building over the entrance or using part of the underground of the building for entrance.

In any case, signs standardized and clearly visualized both in the day-time and at night must be privided at the entrance to the subway. This will serve to promote the convenience of passengers and contribute to the increase of the subway users.

7) Car inspection section

The subject matters of car inspection presently conducted on the subway cars in Tokyo under the provisions of the Local Railway Law are shown below in Table 11-2.

Table 11-2. Subject matters of car inspection

Recurrence of inspection	Matters of inspection	Standard no. of days required
Daily	Operation functions assured and adjusted every day.	A number of hours
Monthly	Inspection and repairs of function limits of the principal part.	A number of days
Every 1.5 years	Overhaul and repairs of principal parts of motors, driving gear, brakes, control equipment.	15 days
Every 3 years	Overhaul and repairs of whole parts.	19 days

The daily and monthly inspection, including small scale repairs, is conducted in the inspection section. Inspection in every 1.5 year and 3 years is performed at the factory which includes repairs for replacement and temporal repairs. Besides, trains are subjected to inspection every morning before getting out of the depot to make sure the functions of opening and shutting of doors and the head-light. Inspection of newly built cars may be scheduled with a little more intervals.

The inspection section will be provided at one end of every line. Facilities required there are the car washing equipment, a wheel roll cutting place, a car inspection shop, a small repair shop and an office. Principal machins used in the abovesaid works are roll-cutting machine, welder, drilling machine, grinder, lifting jacks, overhead crane (3 tons)and air compressor, etc.

8) Workshop

It is advantageous to provide a workshop for cars at one place as viewed from the standpoint of the costs of equipment and the efficiency of the factory. One workeshop is capable of executing works for some 6,000 to 7,000 cars.

The Ohi workshop of the Japan National Railways is assigned with works for 6,000 cars.

Accordingly, a factory will be set up for the subway of this city and all Routes will be connected for common use by trains.

The shops for inspection in every 1.5 years and 3 years and for temporary repairs include those for inspection, dismantling and assembling, bogies, wheels, main moters, machines, car-body, painting, replacing, and office, ware-house, boiler room, air compressor room, as shown in Fig.11-11. When so aranged as shown in Fig. 11-11, about an area of 20,000m^2 will be sufficient enough to perform the work efficiently for nearly 1,000 cars.

Principal machines with which the workshop should be equipped are the overhead crane, traverser, automatic bogie washing machine, parts washing equipment, wheel lathe, form cutting machine, lathes, wheel

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press, drilling machine, electric welder, motor tester, air system testing stand, testing stand for high V., large A. relays, dielectric strength testing stand, ultrasonic wave defect detector, carts, lifting jacks, air compressor and small-size crane etc.

9) Train depot

Originally, a train depot mens a place to retain cars. It, however, is in an inseparable relation with the inspection shop and the work shop. The word, depot, herein used includes them all. An area of $230m^2 \sim 260m^2$ is required per car for a depot including the inspection shop and the factory.

Shown in Fig. 11-11 is a depot having a factory and inspection shop covering an area of $20{,}000m^2$ It is capable of retaining 21 trains in the required area of $46{,}500m^2$. This kind of depot should be prepared at one place for the subway network of Guadalajara City.

Shown in Fig. 11-12 is a depot equipped with retention lines and an inspection shop. This type of depot should be placed at a terminal of every line. The required area is $26{,}600m^2$ and it is capable of retaining 18 trains. It is advantageous, from the standpoint of operation, to install a depot equipped only with retention lines at the other end of the line. Its scale may be decided in conformity to the number of cars used on that line.

The land for a depot is wanted not to apart far from the railway line. Since it requirs a broad area, the main line and the depot must be connected with a side line, if the former is distant from the latter. Usually, a single-track side line serves the purpose, but for a lengthy one double-tracks may be required. A station operated at such place will contribute much to the land development of the district.

3. Execution of construction

1) Topography, geology and earthquake of Guadalajara City (see Fig. 11-13)

Guadalajara City is located in Atemajac gorge in a plateau made up under the effects of Santiago river. The gorge is oval with its 22km-long major axis from Tonala hill northwesterly to Colli hill and with its 17km-long minor axis from the hill of Las Juntas northeasterly to Centinela hill.

The strata of the eastern part of Atemajac gorge consist of the layers of the deposit of volcanic rock, underseas sediments and fossils of the 2nd period of geology. The substratum of Guadalajara City is made up of crushed rocks of the 3rd and 4th period.

The crushed rocks are called "Jalisco rock formation", consisting of sand and heat-crushed rocks like lapilli. At the northeast part of the gorge, the rock formation is composed of glass-like volcanic rocks near Colli hill.

The top soil of this city is of the 4th period stratum comprising volcanic pumice stones and alluvial soil conveyed by water. On the hill of Tonala located to southeast of the city, are observed basalts and tuffs of the 4th period. The northeastern part of the city is blocked in front of Centinela hill by a large valley towards which the whole land of Guadalalara city is graded. Rain water and drainage are gathered towards northeast direction and discharged into the great Santiago river. At the northwest part there are small valleys formed by collaps of the pumice layer.

This city suffered earthquake frequently, with its center somewhere between Zapopan and La Barranca, in a period from May to August in 1912. Thereafter, no heavy earthquake has taken place there. However, there is an earthquake belt running along the cost line from California and passing San Francisco to the vicinity of this city. The activities of Colima volcano near the city frequently cause heavy earthquakes to occur, which, however, is rather weakened before reaching the city.

2) Excavation without road surface cover and cross beams (see Fig. 11-14)

The topsoil of the city which is mostly composed of Jalisco rock formation makes it possible to dig vertically without using the cross beams. Therefore, it is possible to excavate the land without applying the road surface cover at places where the suspension of traffic can be applicable on the road between the sections concerned. At places where vertical excavation is impossible to its full depth, giving of a grade will help the execution of the work. Excavation at places lower than the underground water level should be performed by draining water using a draining pump, well points or deep wells.

Since the work can be done without cross beams and struts, use of large-sized excavator becomes possible here. This results in reduction in the term and costs of construction. A tunnel of stone bond, 3m high, is used as the main sewerage of this city at a depth of about 6m from the ground surface and 4m in width. Judging from such constructions, there is a full possibility for the excavation without the road surface cover and cross beams. The cost of tunnel construction, which accounts for nearly 50% of the total subway construction cost, must be reduced as much as possible.

3) Cutting with road surface cover and cross beams (see Fig. 11-14)

The work without the road surface cover at a road crossing will result in impeding the traffic of the place. Therefore, the road surface cover and cross beams must be provided at the crossings to secure the traffic across the roads under which constructions go on.

For the work at a place with the surface cover, pieces of I-steel, 300mm x 150mm, or H-steel, 300mm x 300mm are driven in as sheathing piles at intervals of $1.5 \sim 2.0$m. On the top of those piles, pieces of channel steel, 380mm x 100mm and those of angle steel, 130mm x 130mm are fixed at a depth of approximately 80cm from the road surface. Pieces of I-steel, 600mm x 190mm are placed as the cross beams at intervals of 2m on the supporting points of the pieces of channel steel. Then the covering boards made of wood, steel, or P.S. concrete are laid in a row above the cross beams for the free road traffic.

Excavation is set downward by putting in sheathing board between I-steel flanges where excavated surface can not hold itself, and wales and struts are also used, if necessary. Sheathing boards or reinforced concrete, wales and struts must be applied at a place near buildings even if the work can be executed without the road surface cover. At a place like the center of the city where Av. Juarez and Calzada Independencia are crossing, the whole roads should be covered and sheathing, wales and struts must thoroughly applied.

At a place like station where sheathing piles are arranged wider than 10m, a supporting pile is driven in between 2 piles, and the length of the cross beam is limited to about 10m. The intermediary piles are cut and removed when the load is shifted onto the upper slab of the tunnel. The intermediary piles must bear the road surface load by their imbeded part below the level of the excavation bottom. Therefore, care must be taken to prevent their sinking.

As regards the temporary constructions required in excavation work with the road surface cover, the stress must be calculated beforehand in relation to the embedment of sheathing piles, thickness of sheathing board, wales, struts, channel steel pieces supporting road surface cross beams, road surface cross beams and covering boards.

4) Road surface covering

Materials used for the road surface cover are wood, steel, Dactyle cast steel, P.S. concrete. Approx. 21cm may be all right as the thickness of the wooden cover, where the weight of a car is 20 tons and the road cross beams are provided at intervals of 2m. Application of wooden covers, 4m in length, continuously for 2 spans to the cross beams provided at intervals of 2m is a reasonable way to save the wooden material. However, should one of the three beams supporting the cover boards goes above the level of the other two due to errors occurring in installing cross beams and deflection of beams, it is liable to incur an unstable state. It is advisable, therefore, to design a simple formation of beams at intervals of 2m, even if it requirs a larger quantity of timber.

The wooden cover should be prepared with non-slip nosing against vehicles running thereon. To apply the material like asphalt and scatter sand thereon is a way for the above purpose.

When steel cover is used, satisfactory strength can be obtained in designing even in case of simple beam, and therefore its length is designed to be 2m. As for its width, about 80cm is deemed appropriate, viewed from the convenience of carring and constructing. Several kinds of steel covers are available such as those made by connecting I-steel pieces, arranging square pipes, made of sheet piles. Those having twisting trend caused by welding strains produced in their making should not be used, as they would cause an unstable state at the site of work. The steel cover is costly, but is using price can be brought down, if so planned as to use it many times because of its long durability.

Merits and demerits of the Dactyle cast steel cover are the same as those made of steel. The thickness of the Dactyle cover can be altered as occasion demands because it is a cast metal. This makes it possible to work out a reasonable design.

The cover made of P.S. concrete is used at places like streetcar tracks where electrolytic corrosion occurs, in spite of its defect—heavier dead load.

5) Steel pile hanging-down method

Used for driving in of sheathing or intermediary piles are a drop hammer or Delmag pile hammer. In either case noises are produced. On a narrow road in the vicinity of important buildings or at the central part of city where noises and vibration must be avoided, the hanging-down method is applied in place of piling by hammer.

The hanging-down method is to dig a hole to the required depth for each pile using an earth auger, then fill the hole with liquidized bentonite mortar to prevent the hole wall from collapsing as the auger drill is brought up. When the drill is full pulled up, the steal pile is put in the hole filled with bentonite mortar. This time the pile is driven in the required extent to insure the upholding strength of the pile. It will be an idea to set concrete at the foot of the pile where such strength is specifically required. The bentonite mortar is applied to prevent the collapsing of the hole wall and to resist the earth pressure. Therefore, it should be so prepared as to obtain the resisting strength which might not obstruct the excavation work. Constructions of the road surface cover, struts, wales, and sheathing boards are preformed in the same way as in case of pile driving in method.

6) Underground continuous wall method

This is a method to dig underground holes or grooves continuously and make their walles by placing concrete or mortar therein. One way is to fill the holes, excavated by the earth auger, with mortar and then put therein the reinforcement cages to make sheathing walls. This method is applied in the streets and the like where noises and vibration are forbidden, or where the underground water level is high and the ground is weak. High cost of construction is a defect of this method.

Icos method is to dig holes using a flat grab, hang down the reinforcement cages into the holes filled with liquidized betonite prepared to prevent the breaking of hole walls, and then set concrete using the tremie tube.

The wall thus made can be used as a permanent constructure of the side wall of the subway tunnel. The reverse process of constructing the upper slab of the Icos wall prior to that of the lower slab is a method of high safety to the nearby buildings and the like. The place where to apply this method, however, should be carefully selected, as the construction costs high and requires a long term.

The French Soletench method is the same in theory with the Icos method, except that in the case of the former excavation is performed by the rotation of the pipe edge and earth and sand are carried away through circulation of the bentonit liquid. The excavator of the Soletench method works effective against solid ground better than the Icos grab.

7) Underpinning of building

During the construction work at a crossing of roads and the like where the subway line is required to be placed under the private land, buildings there are in principle removed and restored to the former state upon completion of the tunnel. Under buildings unfitted for dismantlement or restoration, supporting construction is made thereunder, and the tunnel is constructed. As a supporting means, there is a trench method in which horizontal excavation is made for the part of the tunnel side wall, then for the part of upper and lower slabs, after having the side wall bear the load from the upper part, and thereafter concrete is set. Another method is to prepare deep foundation outside the tunnel or at the middle part of the wall, and by putting in steel beams or by building underground beams, shift the load of buildings onto the deep foundation. Prudent plans must be worked out through thorough surveys on the structure of buildings, the state in which they are used, date of their construction, geological state of the place, and after making economic comparison between those methods.

In case where excavation must be undertaken under or very close to buildings, it is advisable to reinforce the ground under and near the buildings by applying the injection method. The injection method is performed by injecting into ground a liquid agent mainly composed of water glass. The results are heavily affected by the skill of work. Careful work done by widly-experienced workers will produce a thoroughly reinforced ground, which insures safer and easier excavation thereafter. The injection method is also helpful for excavation as a means of intercepting water without lowering the underground water level at places with abundant water.

8) Horizontal tunnel excavation

At the northeastern part of the city where blasting is required to excavate volcanic rocks, horizontal excavation is advisable to lower as much as possible the level of tunnel for 2-track lines. The horizontal excavation makes it possible to continue the construction work without suspending the surface traffic. A larger quantity of dynamite can be used freely there as compared with that used in blasting work at streets, and the tunnel construction work can be executed in a safe and efficient way.

In this case, the tunnel for a station should be designed on higher level and for 2-track line, lower level. To give a longitudinal grade to lines between stations so as to form a valley-like shape is to facilitate the starting, braking, accelerating and decelerating of speed at stations, and thereby offers advantages of easier operation of the train and reduction in electric consumption.

9) Underground installations

One of the underground installations under the roads which affects most the subway construction is the arterial drainage system. The arterial drainage of the city is a tunnel, 4m wide and 3m high, made of piled pebbles. For the most part, this tunnel is located shallow, about 5m from the ground surface to the bottom of the tunnel. Excavation work under this tunnel by applying supports in extremely difficult.

It may be a safe way to provide a bypass for the arterial drainage during the subway tunnel construction. When the subway tunnel is confronted longitudinally with the drainage it is desirable to make a new drainage as a bypass along other road which doesn't interfere with the subway tunnel. This may serve to make easier the free design and execution of the tunnel construction, and occasionally leads to an advantageous result in respect of cost and term of construction. When it is impossible to lead a bypass to other road, a bypass is prepared within the excavated tunnel using colgate pipes (colgate pipes are protected by hanging down). Thereunder, the excavation and concrete setting are executed for the tunnel. The drainage is then restored to the former state above the subway tunnel.

In case where the main drainage crosses the subway line, the subway construction is performed with a temporary bypass of colgate pipes. Upon completion of the subway construction, the drainage is restored to the former state above the tunnel.

In case the subway tunnel is confronted by arterial drainage under unavoidable circumstances, it may be possible to use siphon-structure drainage and place it under the subway tunnel. This, however, leaves problems of making construction scale larger and management and maintenance of the sand pond for siphoning. The relative merits demand and deserve careful study.

Hume concrete pipes are used in local drainage and some part of the arterial drainage. These pipes can be hanged when reinforced by applying caulking at joints.

As for other underground installations, such as water pipe, gas pipe, electric cables, they can be hanged under the road surface support beams during the tunnel construction. They may be restored to the former state after completion of the tunnel construction. This time attention must be paid not to cause accident to underground installations resulting from the sinking of the back-fill earth after the completion of tunnel construction.

10) Other method

In the construction of the subway tunnel methods other than previously stated ones are used which are introduced briefly as follows.

(1) Shield method

This is a method to make a tunnel by forming rings with the precast segments one after another behind the cylindrical excavator that goes ahead covering the full cross section of the tunnel. Excavation is executed manually or by machine and under high or normal atmospheric pressure according to geology and the height of the underground water level. Materials used for the segments are reinforced concrete steel, Dactyl cast steel.

(2) Pneumatic caisson method

This is to make a part, about 25–30m long, of the subway tunnel into an air-tight caisson, and excavate the ground under the caisson in the compressed air, and then the caisson is sunken. In this method the air pressure prevents the inflow of water, and therefore, it is used in tunnel construction at places where unerground water level is high and the ground is weak or at places where the tunnel goes across a rive.

(3) Freezing method

This is an ideal method that facilitates excavation work by reducing the earth pressure and preventing water from gashing out by means of freezing water in the earth. However, it is a costly and time-consuming method. Voluminal expansion tends to cause the surface constructions to rise and the work efficiency is lowered when the underground water is in a fluid condition. It thus leaves technological problems to be solved.

Fig11—1

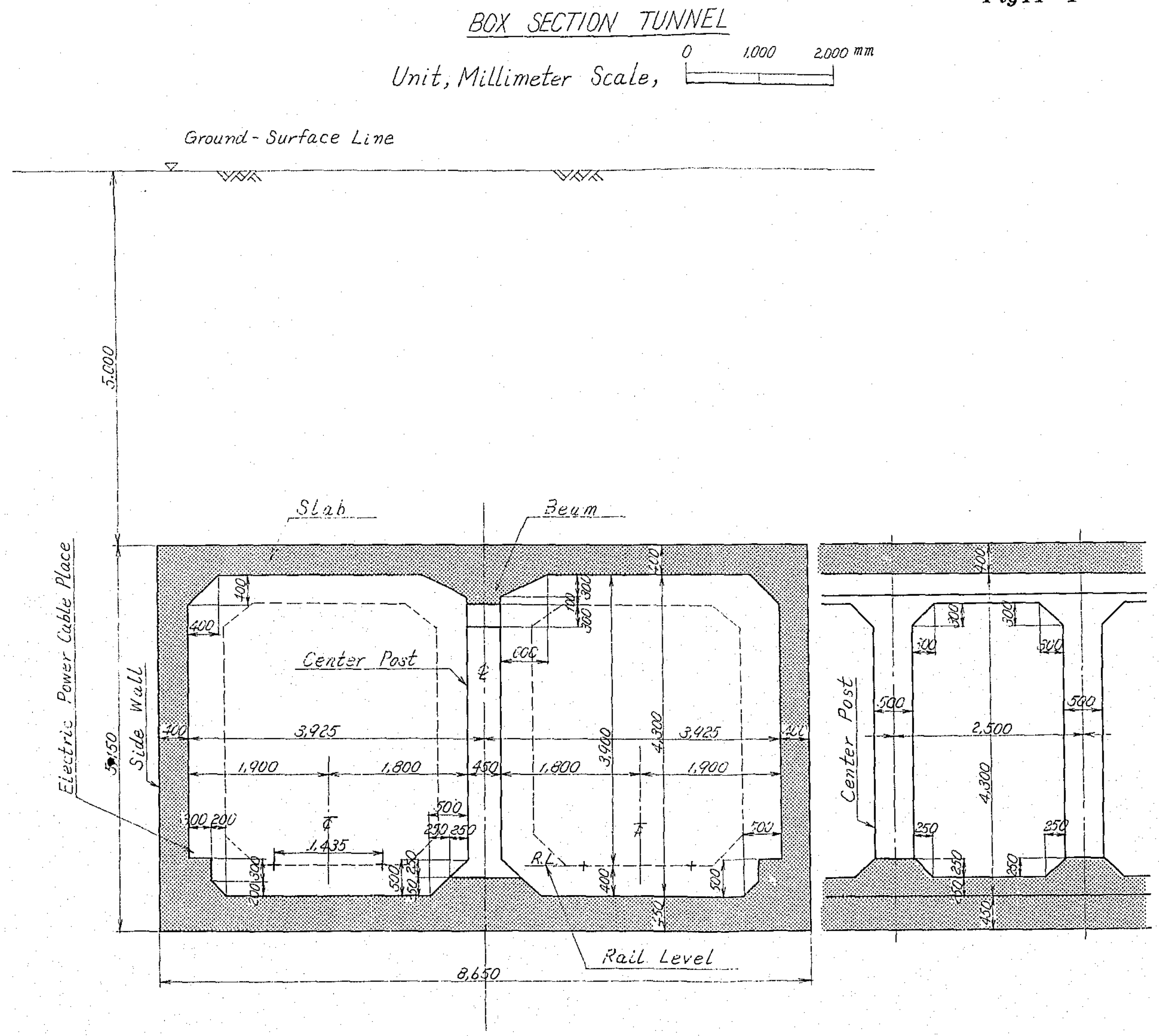
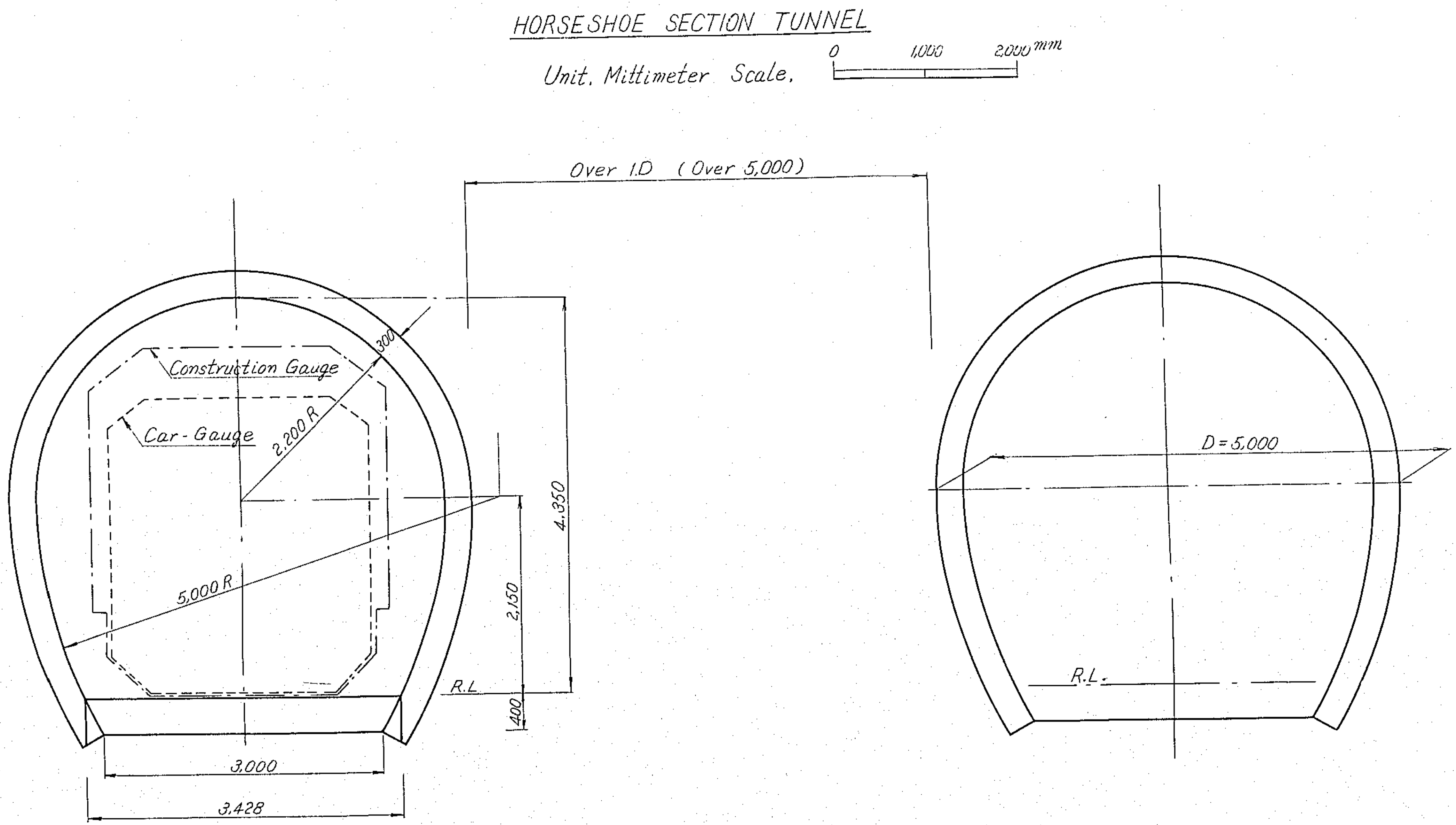

BOX SECTION TUNNEL
Unit, Millimeter Scale,
0
1,000
2,000 mm
Ground - Surface Line
5,000
Slab
Beam
Center Post
Electric Power Cable Place
Side Wall
3,925
1,900
1,800
450
1,435
4,300
3,900
2,500
R.L.
Rail Level
8,650

Fig 11—2

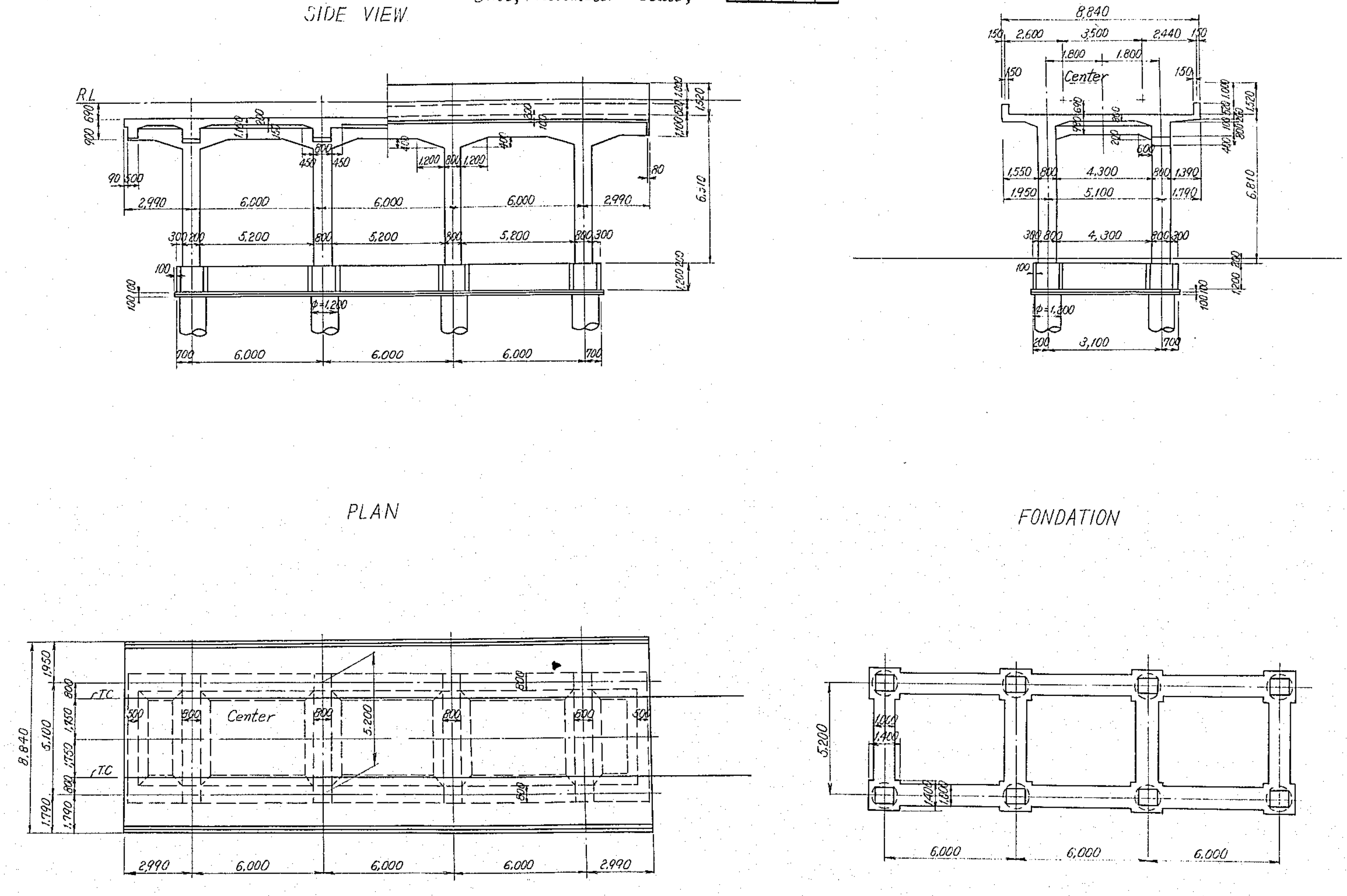


HORSESHOE SECTION TUNNEL
Unit. Millimeter Scale.
0
1,000
2,000 mm
Over I.D (Over 5,000)
300
Construction Gauge
Car - Gauge
2,200 R
4,350
5,000 R
2,150
R.L
400
3,000
3,428
D = 5,000
R.L.

Fig 11—3

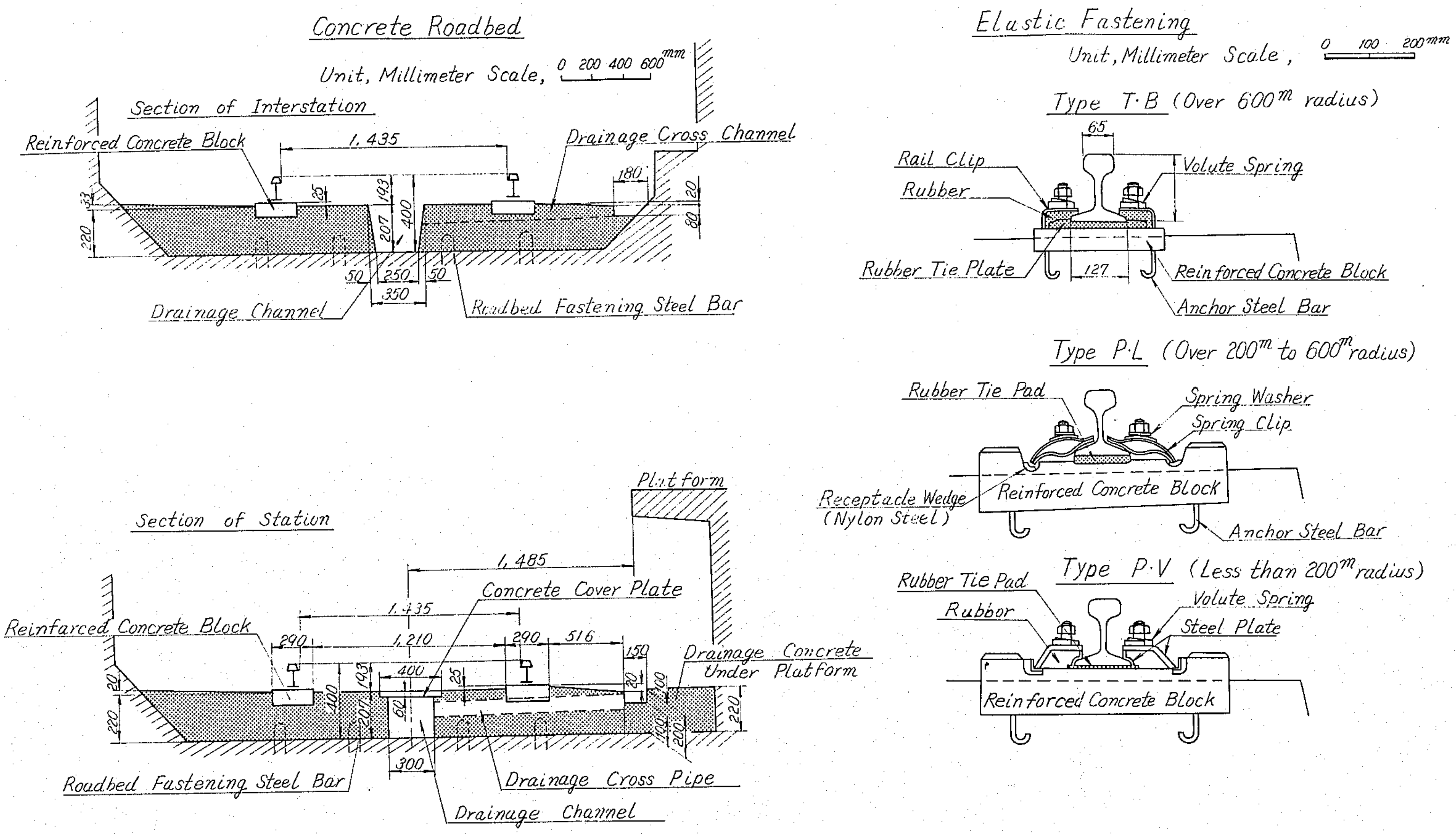
ELEVATED RAILWAY STRUCTURE

Unit, Millimeter Scale, 0 — 5m



TRACK STRUCTURE FOR CONCRETE ROADBED

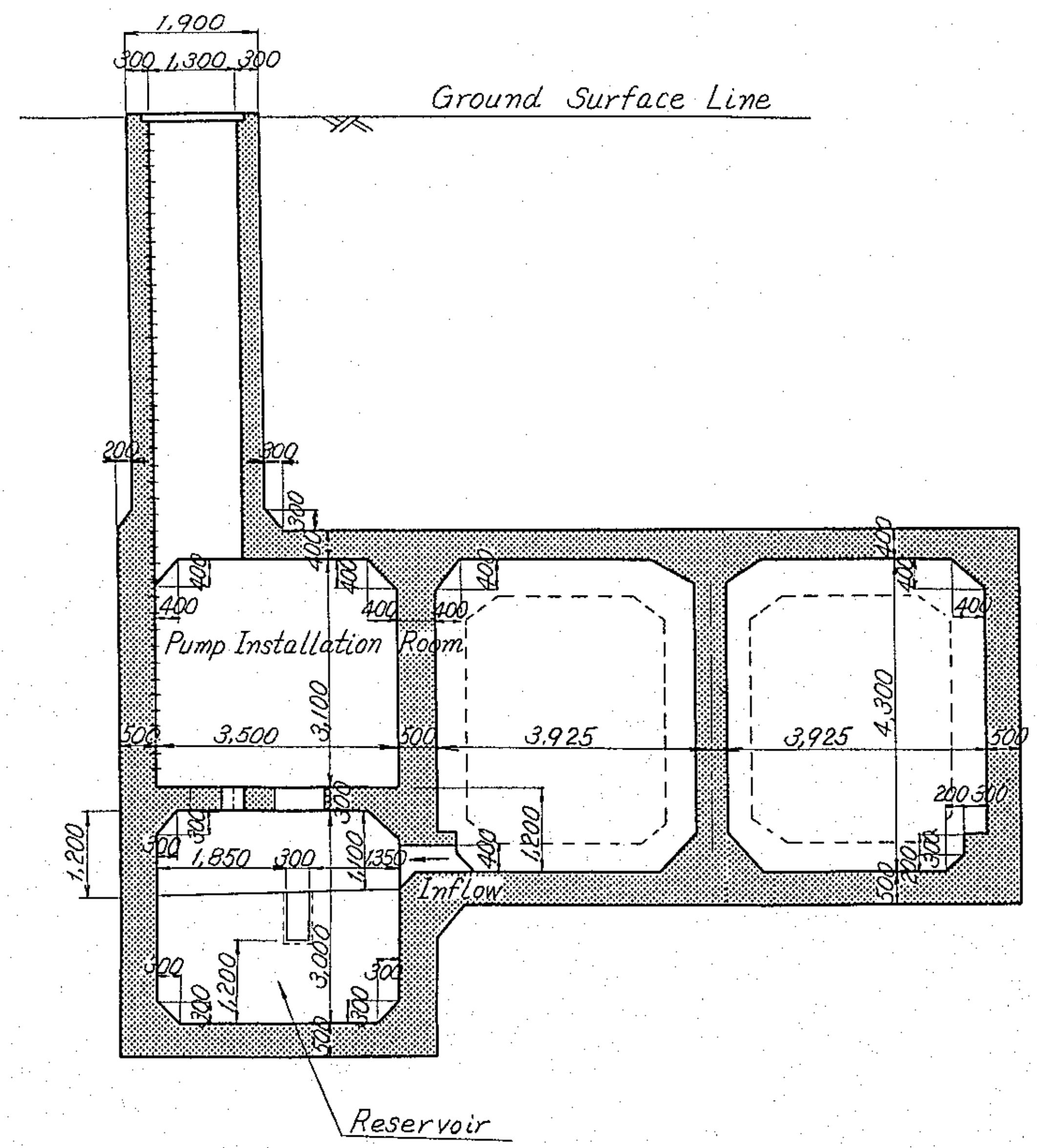
Fig 11—4



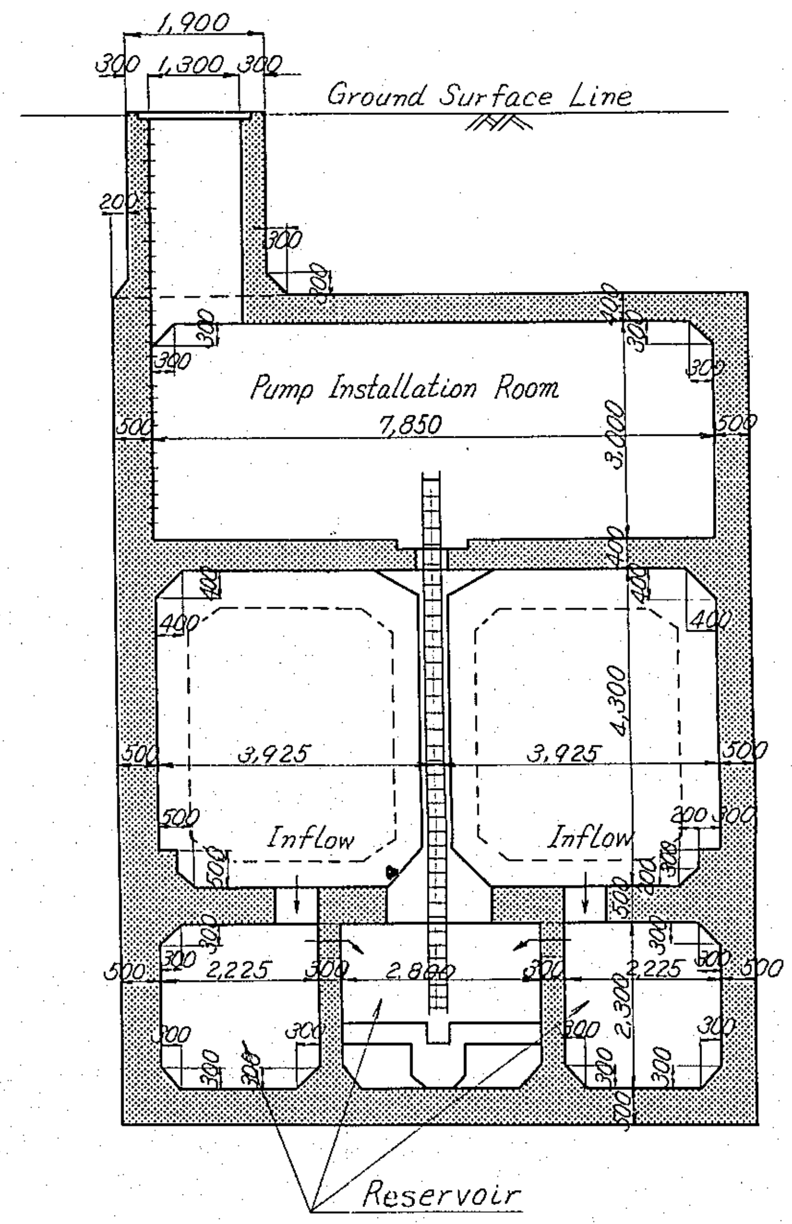
STRUCTURE OF DRAINAGE PUMP ROOM

Unit, Millimeter Scale, 0 1 2 3m

Side Room Type **Fig 11—5**



Under Room Type **Fig 11—6**



ISLAND PLATFORM STATION SECTION

Unit, Millimeter Scale, 0 1,000 2,000mm

Fig 11—7

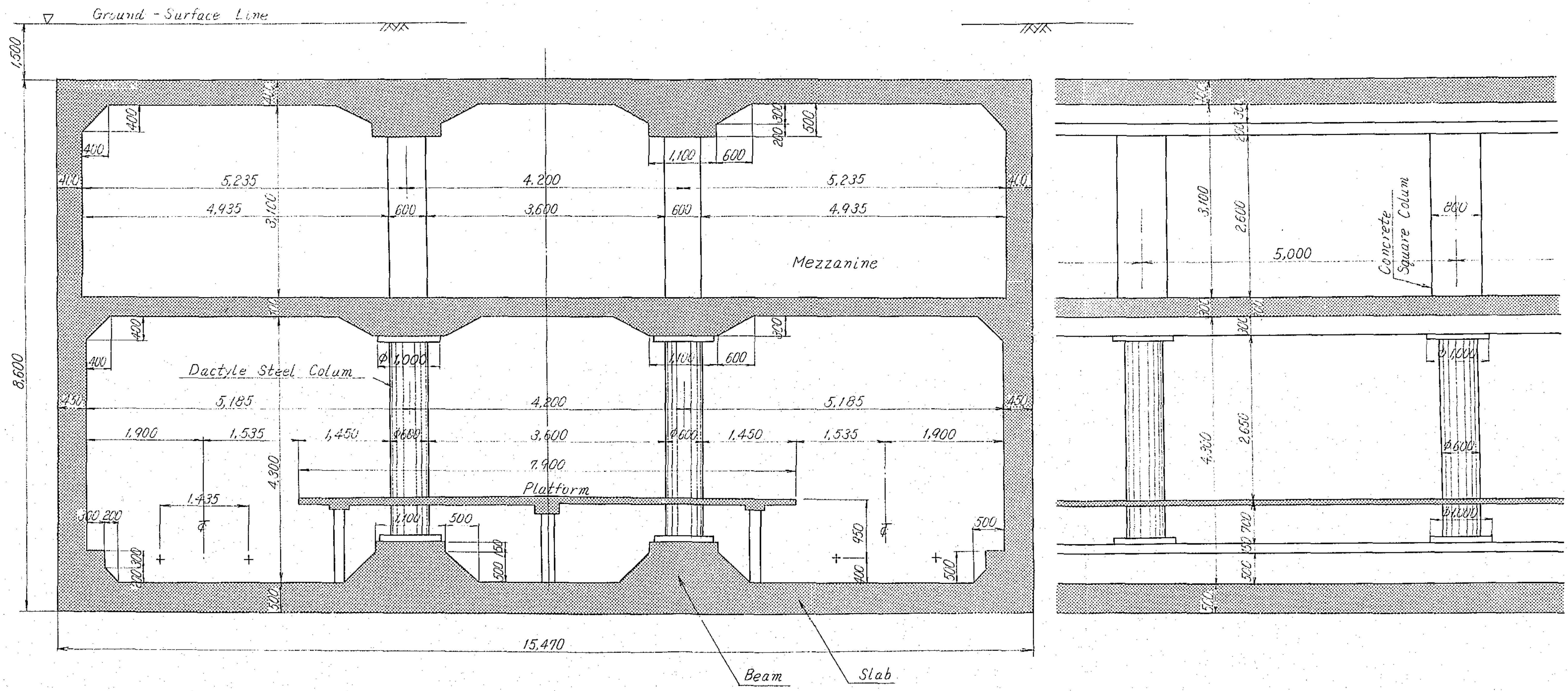
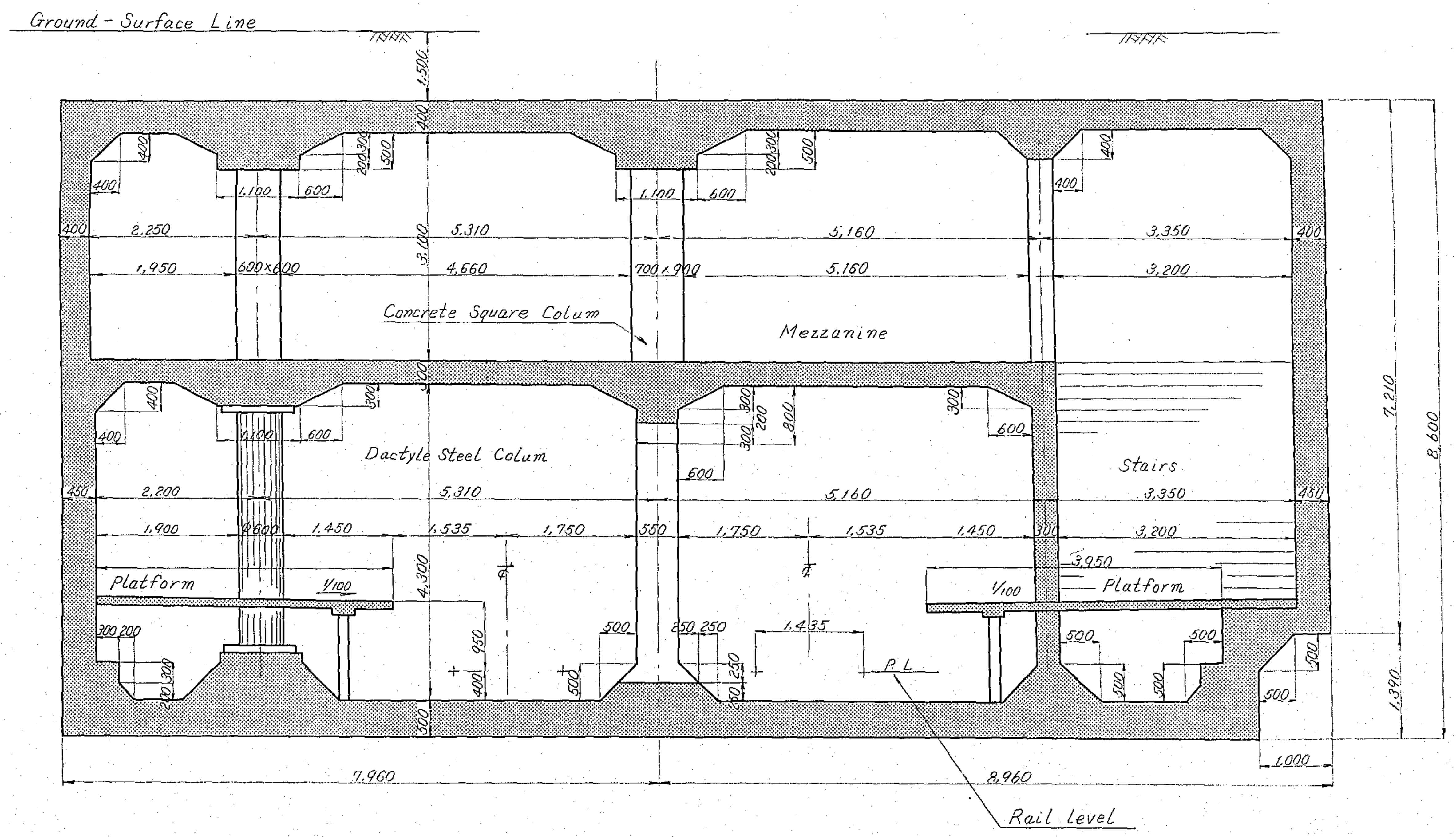


Fig 11—8

SEPARATE PLATFORM STATION SECTION WITH MEZZANINE

Unit, Millimeter Scale, 0 1,000 2,000 mm



SEPARATE PLATFORM STATION SECTION

WITHOUT MEZZANINE

Unit Millimeter Scale

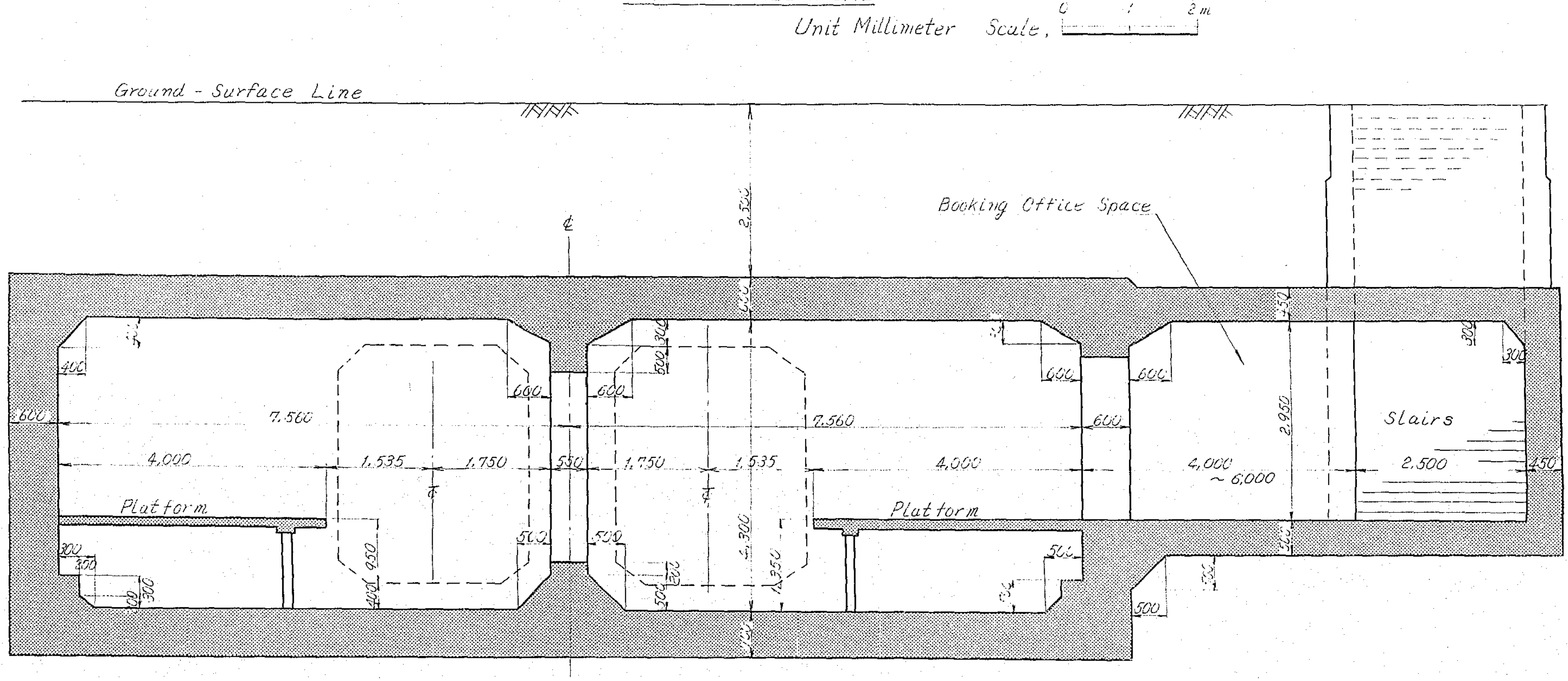
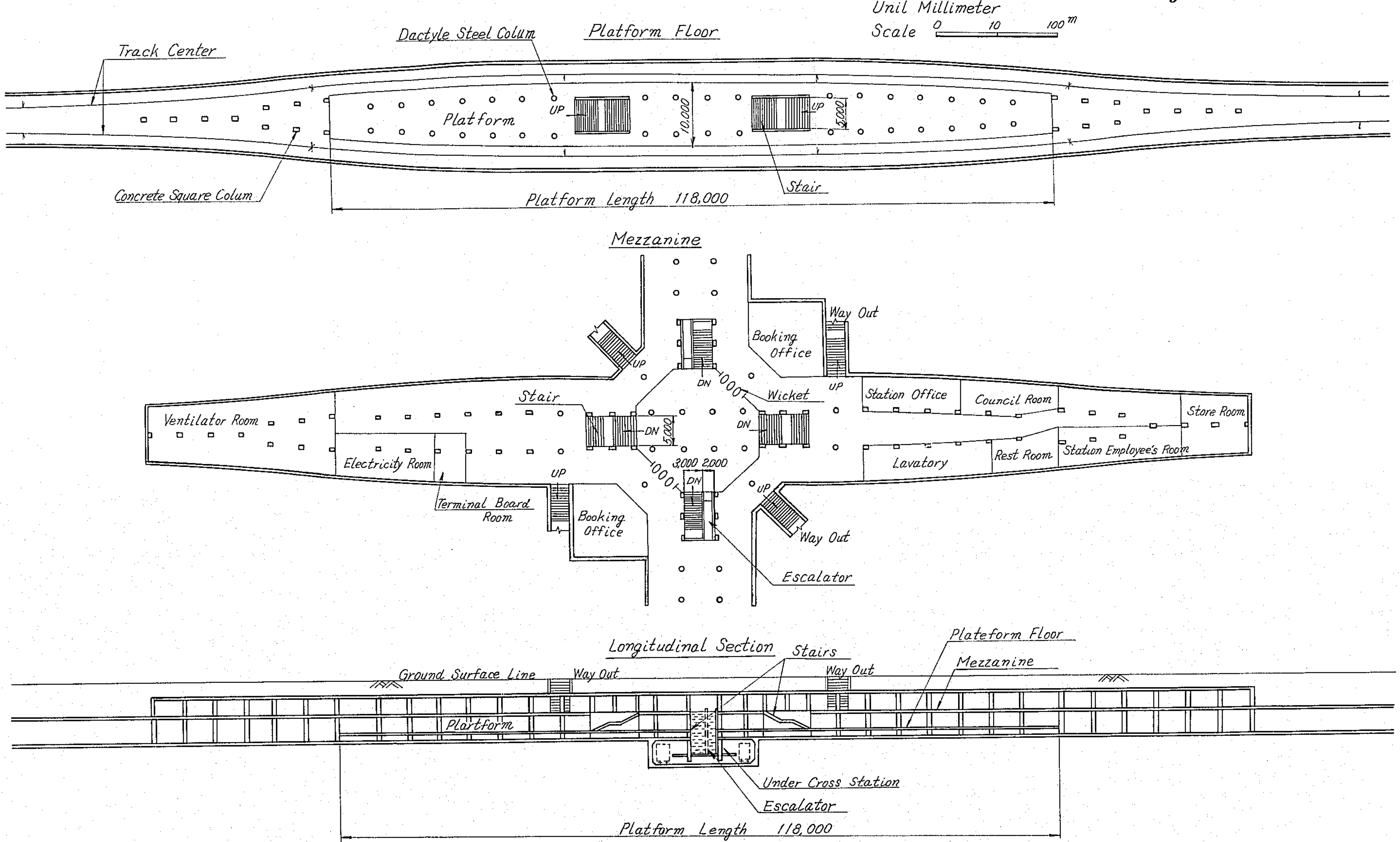


Fig 11—10

GENERAL PLAN OF CROSS STATION

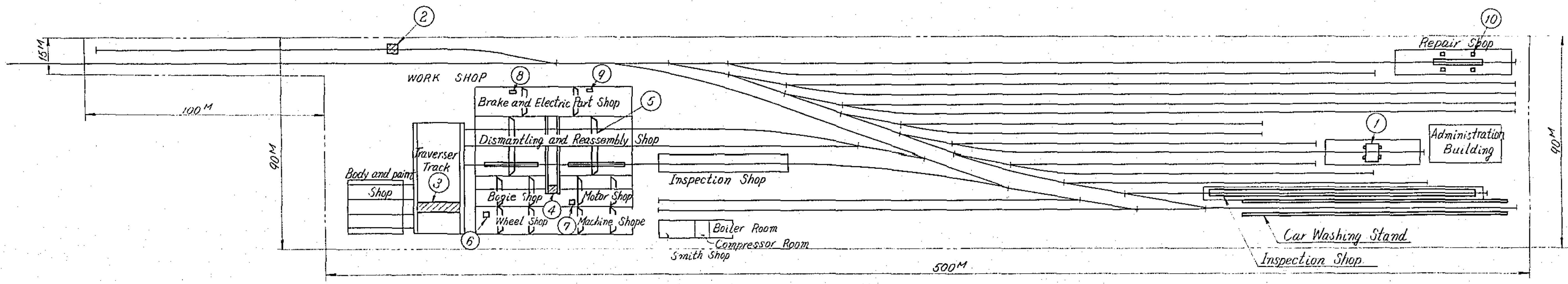


PLAN OF THE CAR SHED TYPE A

Fig 11—11

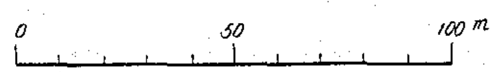
Area of the site, about 46,500 M^2

Capacity, about 126 cars (6 cars × 21 trains)



	Name	Number
①	Tire Milling Machine	1
②	Automatic Car Washer	1
③	Traverse	1
④	Automatic Bogie Washer	1
⑤	15ton Over Head Crane	1
⑥	Tire Lathe	1
⑦	Rolary Tester	1
⑧	Brake Valver Tester	1
⑨	Relays Tester	1
⑩	Lifting Jack	1

Scale,

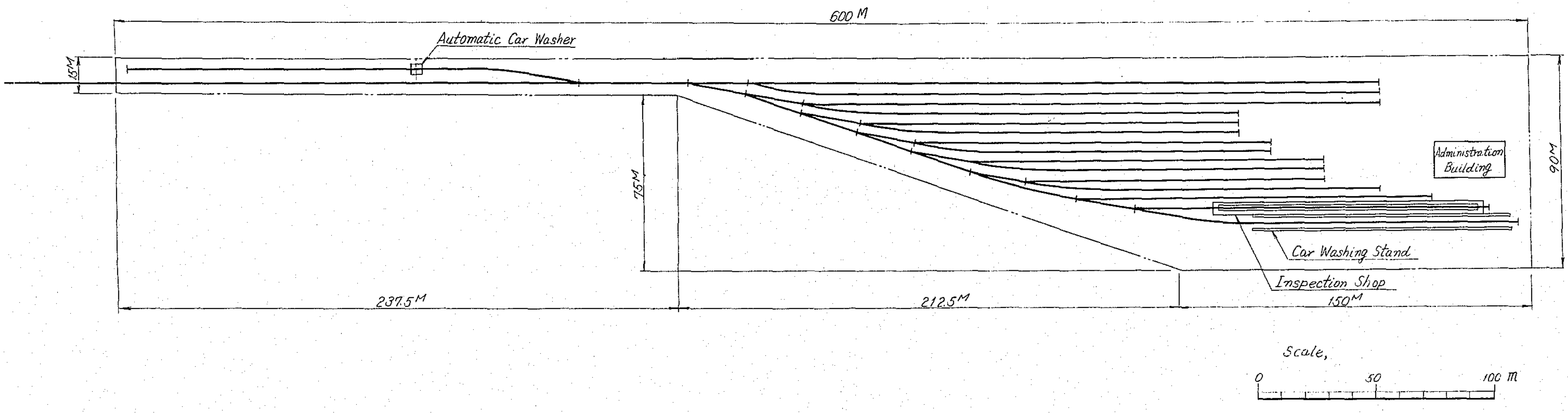


PLAN OF THE CAR SHED TYPE B

Fig 11—12

Area of the site, about 26,600 M^2

Capacity, about 108 cars (6 cars x 18 trains)



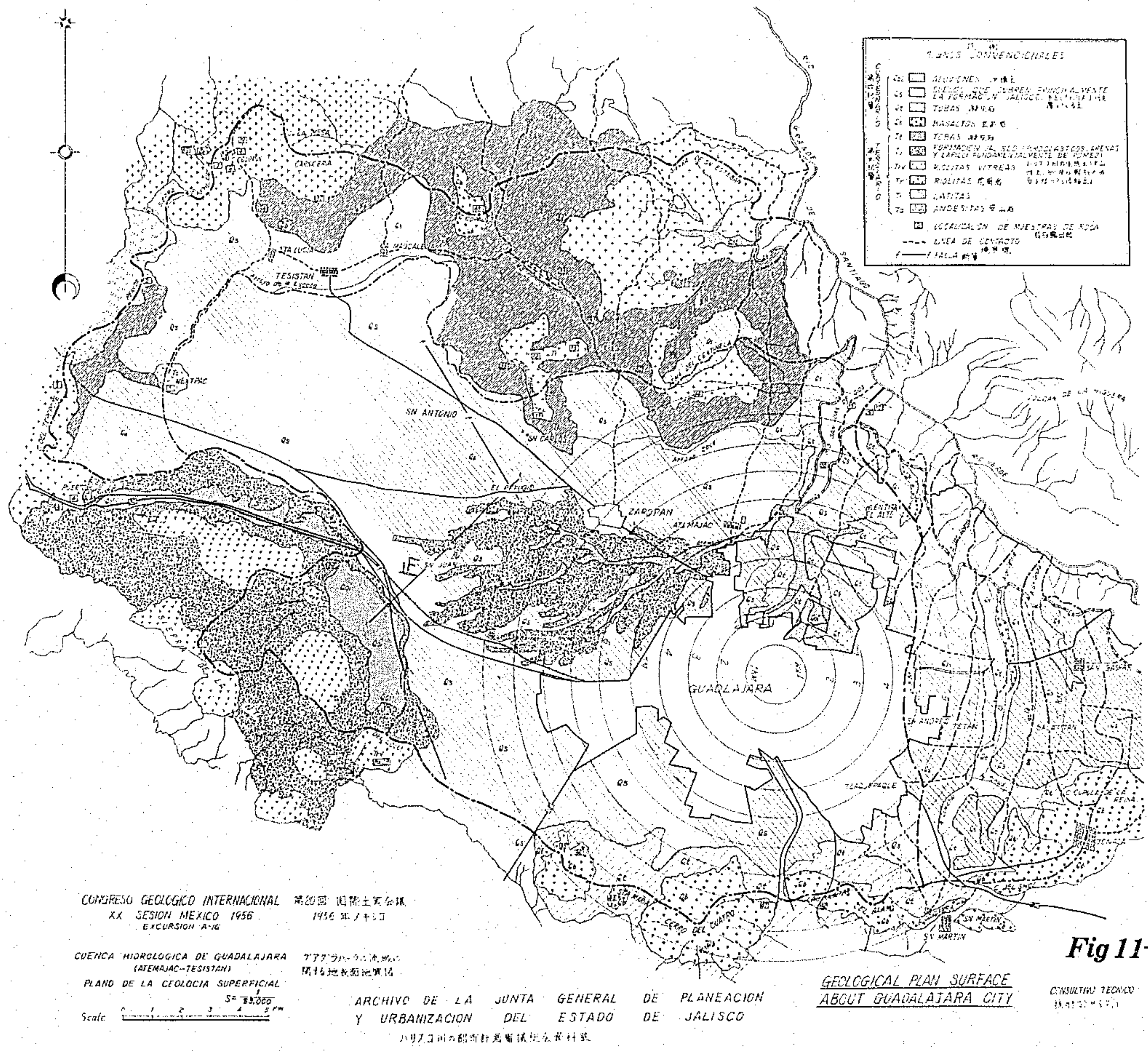
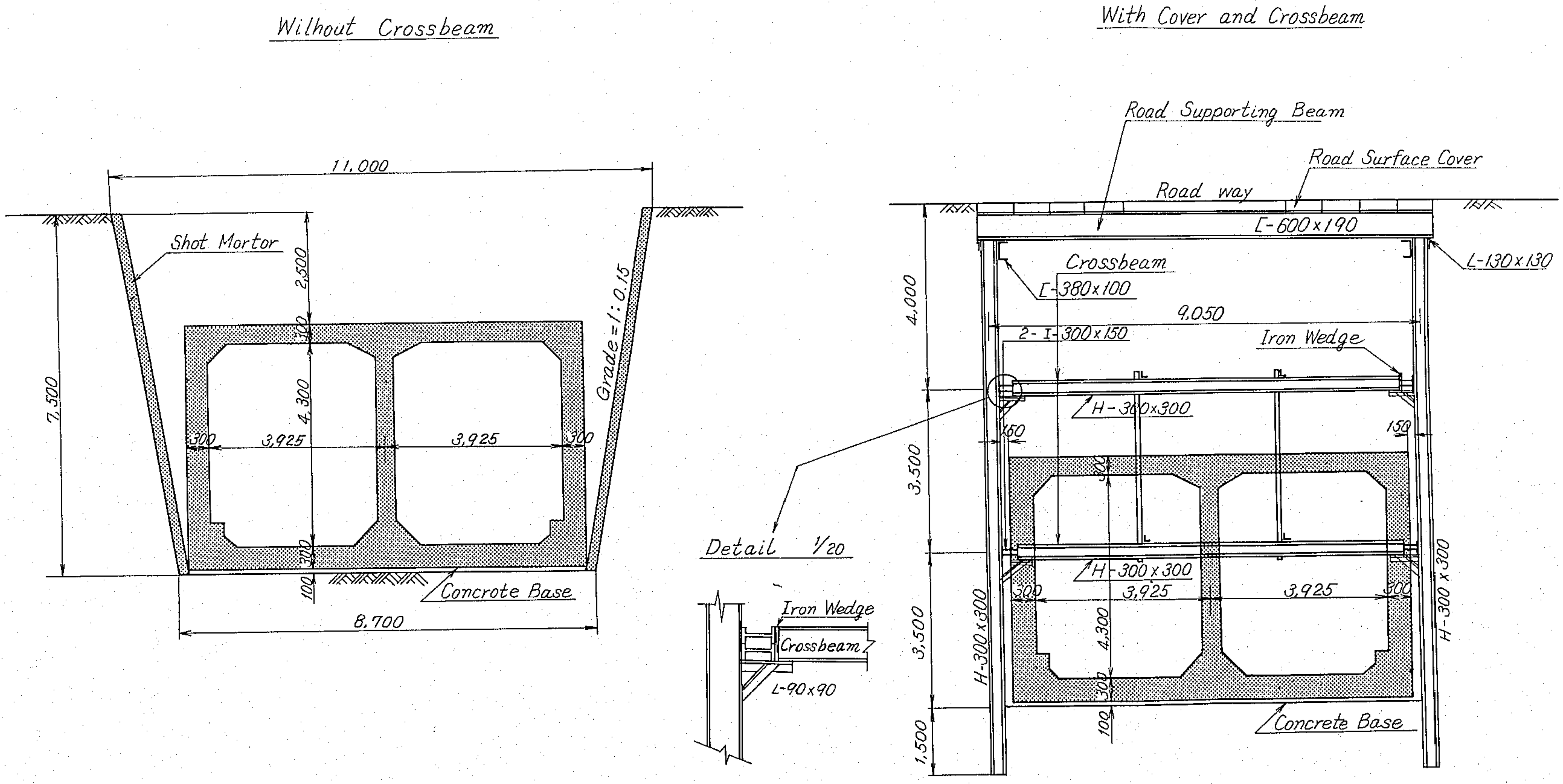

GUADALAJARA
ZAPOPAN
TESISTAN
SAN ANTONIO
CERRO DEL CUATRO
SN MARTIN
CONGRESO GEOLOGICO INTERNACIONAL
XX SESION MEXICO 1956
EXCURSION A-16
CUENCA HIDROLOGICA DE GUADALAJARA
(ATEMAJAC--TESISTAN)
PLANO DE LA GEOLOGIA SUPERFICIAL
Scale
ARCHIVO DE LA JUNTA GENERAL DE PLANEACION
Y URBANIZACION DEL ESTADO DE JALISCO
GEOLOGICAL PLAN SURFACE
ABOUT GUADALATARA CITY
CONSULTIVO TECNICO

Fig 11—13

Fig 11—14

STANDARD OPEN CUT EXCAVATION METHOD

Unit, Millimeter   Scale, 0 1 2m



CHAPTER XII. ELECTRICAL FACILITIES AND DISASTER PREVENTION FACILITIES

1. Transforming facilities

No reference is made in this chapter as to the power supply route running up to the respective subway transformers since a separate plan will be formulated.

Power, after received at 20kv from the power supply route, will be transformed at the main transformer station of the subway and supplied to each of the transformers provided at intervals of about 2km distance. In the case of subways, such transformer substations, being considered difficult to be installed in between the subway stations because of the dificulity of land purcharsing peculiar to the subway site, are provided within the premises of appropriate stations selected at intervals of about 2km distance.

Power will be transformed to 750v DC by a rectifier at the respective transformer substations located in the station premises, and will be supplied to the 3rd rail track. Considering the maintenance and performance, the rectifier shall be of silicon type. The incidental power will be transformed to some 3.3kv AC by the respective transformers, and will be supplied to each station.

Each subway station will have the power receiving facility where the supplied 3.3kv power will be changed into 100–200v AC for use of lighting, drainage pumping, ventilation and for other purposes. Power is supplied to the respective transformers by cable which will be suspended against the tunnel wall.

It is desirable that all transformers for use by subways are provided with two or three supply routes in consideration of possible power failure or other defects so that automatic change of switch can be performed in case of any trouble. Also, it will be advisable to have a main transformer provided at each location from Route No. 1 to Route No. 4 so that any failure or trouble can be kept at its minimum.

All transformer substations provided in the premises of selected subway stations shall be of no-man type with an independent automatic control panel which may require only periodic inspection. A central control board will be located in the power control center for control of all lines.

All failures or defects occurring at each of the transformers located in the subway station premises will be communicated to the power control center which will then direct all necessary instructions.

2. Power supply facilities

The source of power for the electric cars will be of 750v DC, and the method of current collection will be of the third rail system. As this subway system is designed mainly for urban transportation purpose, there is no need of considering a direct passage of large scale intercity transportation and, therefore, in consideration of the economy of the cross section space of the tunnel, catenary method will not be used.

The power source for all lighting, water supply and drainage, ventilation system, and other incidental facilities shall be of 3.3kv AC which is received by the power receiving facility at each of the subway stations and is transformed into 100–200v AC. The lighting is considered to have 500–800 lx (on the table level) in the office, and 400–500 lx (floor level) in the platform concourse. The lighting will be of fluorescent type.

Drainage system will have water deposits at appropriate intervals in consideration of the railway gradient. The water will be drained from the deposits by pumps. It will be advisable that the capacity of the pumps be determined in consideration of the underground water level, railfall, and the water amount used by the stations, however, for the sake of safety, the capacity of the pumps is recommendable to have about two times of the average water amount expected.

All such transformers and power receiving facilities shall be provided with their respective housings with a sign of "Electric Room", which is advisable to have an appropriate ventilation, if such equipment generates a large voluem of heat.

3. Signal and safety facilities

For signaling and safety facilities, it is desirable to adopt such A.T.C. and C.T.C. systems as actually practiced by the Japanese National Railways with the New Tokaido Trunk Line.

The signal system shall use the track circuit and the speed signal shall be transmitted from the ground based radio transmitter to the receiver installed in the car, thus automatically indicating the speed signal so transmitted. In view of the speed of the trains and the length of the block section, the system shall comprise five indicators.

By these speed indicators, the speed of the train will be automatically controlled, and in case of any overspeed, the power circuit will automatically cut off and the brake will work itself. This system will eliminate the necessity of any ground signal facilities.

Furthermore, in order to give higher efficiency of performance as a commuters' train, it should be considered that a largest possible latitude of accelerration and deceleration should be given, and that the distance in between the block sections should be limited to the minimum length possible so that the trains can be operated in maximus numbers.

Also, further consideration shall be given for the future when A.T.C. operation can be performed by installing additional ground or on-the-train signal system.

With this A.T.C. system adopted, the train shall become almost complete automatic operation, and the electric car operator's job will be nothing but to watch the safe moving of the train. However, such A.T.O. system should be employed after a deliberate calculation weighing all the involved factors such as investement, economy, labor, etc.

All train operation through the entire subway line shall be covered by C.T.C. system. All signals at the respective stations and the operation of the trains shall be communicated to the central control command which shall have a central train operation chart board showing the locations of all trains in operation, and shall communicate with each of the operating trains by radio telephone system to give out necessary instructions at any time when so required, and at the same time, shall take necessary action for synchronizing of signaling and switching.

4. Communications facilities

The communications facilities comprise two telephone systems. One is for general clerical and business purpose, and the other is for exculusive use of power supply and instruction isssuance.

In view of the importance of general clerical and business communications and the urgency of operational message and contact, the telephone system is recommended to be a combined type of exclusive subway line and the general purpose civil line, while the instruction issuing telephone system shall be radio telephone having the central control command as its base station. This base station will handle and issue all communications and instructions to each of the subway stations and the operating trains.

It should be considered that the radio installed on the train should be the type of guided radio system. Installation of such system is a "must" in view of the absolute necessity of emargency communication.

Aside from this, an additional emergency communication system should be provided to enable the maintenance men to report immediately any unusual findings that they may encounter during their maintenance patrol.

5. Disaster prevention facilities

The subways, which unlike the railways on the ground, have the railways and station buildings under the ground, should be provided with all conceivable safety and disaster prevention measures for the protection of the passengers and the personnel working for the subways. The conceivable disasters may include fire, flood, power interruption, etc. For prevention of fire, effort should be made to remove all possible causes of fire. For this purpose, cars must be built with non-inflamable materials as much as possible, and meximum limitation must be placed against the inflamable fixtures. Thermal detectors, smoke sensors and I.T.V. are recommended to be installed so that fire can be detected and alarmed at its earliest stage. For this, an early alarming system should be provided.

In order to minimize the disaster as less as possible in case of emergency, elaborate studies should be made to prepare emergency exits for passengers to be guided to the safety. Also, providing against any fire which may break out, a fire control or extinguishing system as well as fire fighting squads must be organized to fight and control the fire at the earliest possible opportunity. Consideration must also be given to the control of smoke which will be disastrous in case of a subway fire. So, appropriate smoke discharge outlets and fire shutters to prevent further extension of fire must be provided.

As for the flood, the possibility of subway flooding must be calculated based on the data and information on the rainfall, water-channels and extent and scale of floods in the past years in the Gundalajara area, and due consideration should be given whether it will be necessary to provide certain numbers of pumps of required capacity or water-gates to shut out the possible flood.

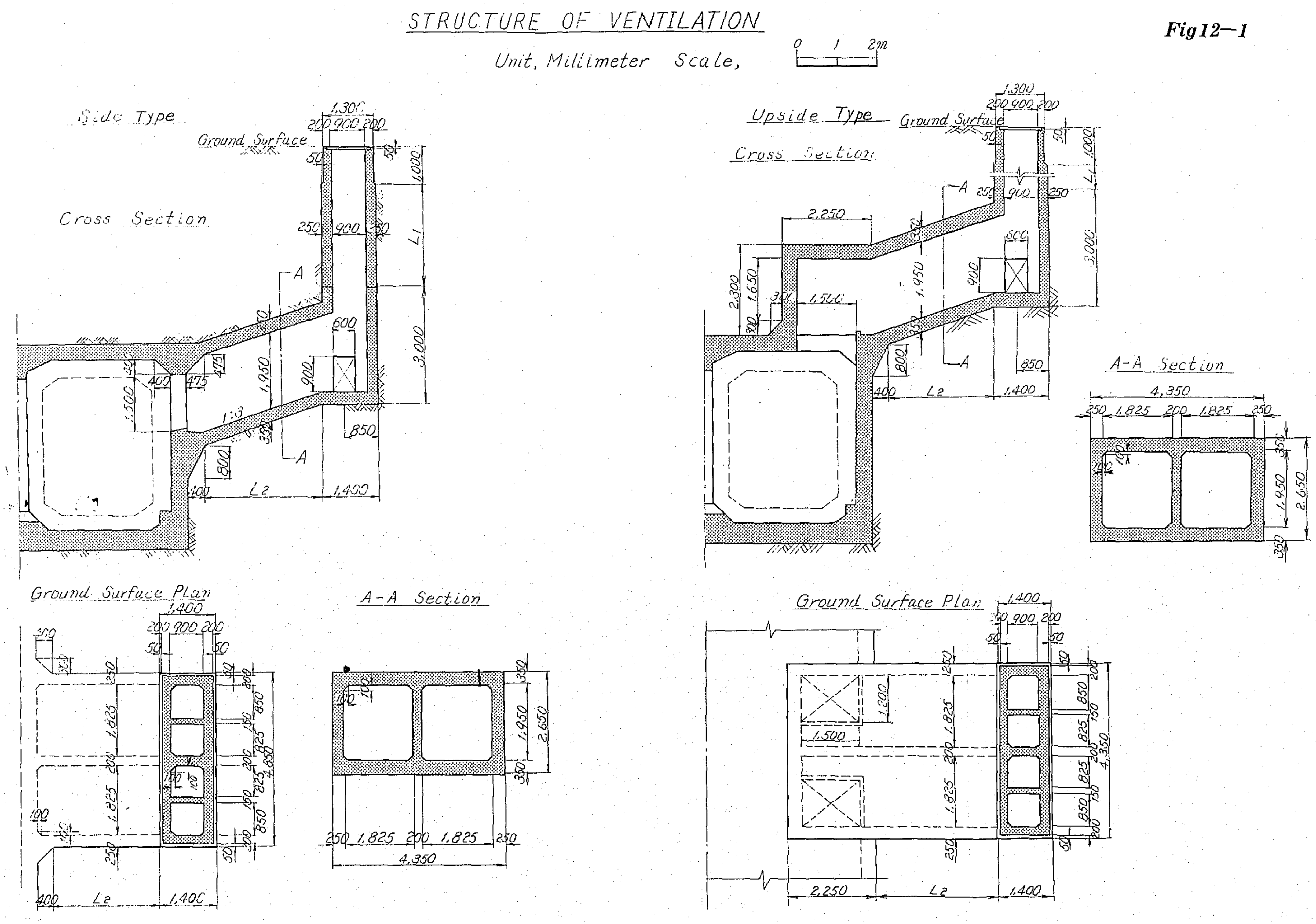
As for the power interruption, the conceivable caused may be by some troubles at the power source, or by fire, flood or other disastrous accidents. Providing against such power failure, it is necessary to conisder about an emergency power generator or an auxiliary power source to secure the lighting in the subway stations and their premises, ventilations, etc.

6. Ventilation facilities

1). High temperature and humidity inside the tunnel

The heat which is generated inside the tunnel is mainly from the human bodies, lighting in the premises of the stations, and the power consumption of the electric cars including the heat from the railway and car wheel friction.

Fig12—1


STRUCTURE OF VENTILATION
Unit, Millimeter Scale,
0 1 2m
Side Type
Cross Section
Ground Surface
Ground Surface Plan
A-A Section
Upside Type
Cross Section
Ground Surface
A-A Section
Ground Surface Plan

With the increase of passengers and trains, the tunnel is apt to be filled with uncomfortable air of high temperature and high humidity because of the insufficient heat transmission from the structural wall to the earth and poor ventilation.

The heat transmission from the structural face into the ground may differ according to the underground water level and the geological nature of the locality. However, during the initial stage of the subway operation, when yet the number of passengers and trains may not be very many, the temperature, or heat build-up in the tunnel may not risr too high as the heat transmission is expected pretty much. But following the increase in the numbers of passengers and trains, it may become difficult to depend on the heat transmission and the built-up heat must be discharged by mechanical ventilation.

2). Natural ventilation.

The heat generated by the train in the tunnel in between the stations can be discharged by natural ventilation. The natural ventilation holes through to up-ground will be provided in the tunnel at appropriate intervals, and the running train will play the role of a piston intaking fresh air and exhausting the heated air from the vent as the train runs through the tunnel, thus necessitating no blowers for mechanical ventilation. However, for the station platforms, where the heated air is whirled up from the incoming train and the high temperature is generated by the stopping trian, passengers, lightings and by other sources of heat in the station, a mechanical ventilation is required.

The natural ventilation holes shall be as indicated in Fig. 12-1 in the case of the box-type tunnel with two tracks. Such type of vents shall be provided at every 80–100m. The vent shall be horizontal as a standard, but according to the topographical condition, it may be vertical or shaft type. The natural ventilation holes, if the tunnel runs deep underground, shall be located in close intervals as the vents becoming longer will become less efficient.

3). Mechanical air conditioning.

It is the disadvantage of the subway stations that the air flow is limited only through the station's entrance and exit, whereas it is essential that a due consideration be given to the installation of mechanical ventilation or air conditioning system. In this case, a ventilation at the rate of approximately 30 $m^3/m^2/h$ is required for the area used by people. For a mechanical air conditioning, a machine shed (blowers for intaking and exhausting, power receiving set, and control switches) and air ducts must be installed in the station premises, while up on the ground a vent must be opened which should be several meter high from the ground level. The machine shed (machine room) need to be more than 4m high, and its floor space may be considred about 200m^2 for one station if it is for use of ventilation alone. The vent space will be designed for sufficient air volume to allow 7~8m/s wind velocity.

It can be assumed that the temperature at the station platforms will rise 4~5°C higher than the outside temperature in summer time with the increase of incoming and outgoing passengers and trains at the station after a few years of the operating of the subways, and that such high temperature will cause an unpleasant environment to the passengers. Whereas the installation of air conditioning may become a subject of special consideration. When an airconditioning system is considered, there will be necessary, beside the ventilation equipment, a cooler or a refrigerator, air-controler, pumps, piping, cooling tower, etc. for which additional space for the machine room in the station premises and an extra space for the cooling tower up on the ground must be secured.

For better efficiency and saving of the operational manpower, it is advisable that the control of all such ventilations or air conditioning systems will be centralized to the Central Control Board instead of each station handling them.

CHAPTER XIII. THE PRIORITY OF THE EXECUTION OF CONSTRUCTION AND THE TIME FOR COMPLETION OF THE WORK

1. **The Priority of the execution of construction**

1). Introduction

Reviewing and study will be made as to which line of the projected subway system as related in Chapter VII will first start the construction.

The condition which will decide the priority of the execution of the construction work accords almost with the conditions described in Chapter VI, the details of which are given as follows:

(1). A transfer from the surface transportation should be considered, especially, the transfer from the bus transportation must be given a priority attention.

In view of the mission of the subway transportation, which is to carry a large mass of passengers efficiently and at high speed, the construction work of the subways should be started from such sections which will best meet such requirements.

(2). The crowded street traffic must first be relieved of its congestion.

As part of the duty of the high speed subway transportation is in the relaxation of traffic in the central area of the city, the construction should be completed as soon as possible from the most traffic congested area to ease such street traffic trouble.

(3). Upon opening the subways, a car-depot and a repairshop must be secured.

Any short subway section should have secured a train depot and a repair-shop for the maintenance of the electric cars.

(4). The initial operational distance must be 5km or more at the shortest.

From the past experience, it has been learned that the initial operational subway section must be more than 5km at the shortest, otherwise, it would be difficult to get the satisfaction of the passengers, and would be operationally uneconomical and inefficient.

(5). The selected line should be easier for construction and be possible for earlier completion.

For the initial construction section, an easier section should be selected where the road is wide and not obstacled by crowded houses or buildings, and the underground is clear of burried objects and geographically favorable. If not absolutely necessary, any section where a difficult work is anticipated should be eliminated from the initial work schedule.

(6). The route connecting the most developed area with the center of the city should be selected.

The high speed transportation should be directed to the highly developed area or any area where future high development is expected so that such high efficient transportation may encourage and promote an urban development, and at the same time, to absorb part of the increasing traffic of the central area of the city into the underground transportation, thus the worsening congestion will be greatly eased.

Reviewing the general subway system from the above point of view, the construction work should be commenced in the order of Route No.1, No.2, No.3 and No.4.

2). Route No.1

Route No.1 is a route running east-west through the central area of the city along Av. Juarez and Av. Javier Mina. This line should be the first to be completed as its services are essential for the transportation of a great mass of commuters from the densely populated area extending on both sides of Av. Javier Mina and at the same time to ease the street traffic congestion in Av. Juarez.

San Andres district, the east-side of the city, is a residential area, and acquisition of land for train depot and car repair-shop is expected very difficult, while the city's south-west side, the district of Ciudad del Sol, has still many vacant lots along Av. Lopez Mateos, and this area will be desirable to install the car-depot and the workshop for car repair and inspection.

In order to cope with the traffic which is generated from this district toward the central part of the city, it is necessary to complete the line extending to the civic center at one time. Consequently, it can be considered as most appropriate that the initial operating section should cover the line from Ciudad del Sol to Av. Lopez Mateo and Av. Juarez and extend to the station next after the junction station linking Route No.3. In this case, the length of this section will be 9km.

In Av. Lopez Mateos district, the city's main sewerage duct being running under west side of the road, the subway line must be built along the line of the east-side half from the center of the avenue. In Av. Juarez, as the ducts are burried underneath the central line of the street, it may be necessary to move the duct to one side of the road or other street, so that the subway line will have a sufficient space.

The two existing underground passages in the center of the city will be closed for the length of the subway construction period, but these underground passages may be used as the concourses for the subway station, and may be utilized as the entrance and exit for the station.

The construction of 4.6km line between the center of the city and San Andres will follow then, and thus Route No.1 will be entirely completed.

3). Route No.2

Route No.2 will serve for transportation running from Zapopan and Tlaquepaque districts to the center of the city, and will also be responsible for the traffic which is generated at the Central Bus Terminals, which is the base for the arriving and departing busses between other cities and Guadalajara. The train depot and the car repair and inspection workshop are recommended to be located near the elevated railway in the sout-east part of Zapopan along Avila Camacho, as in such area, acquisition of land and construction work are considered very easy.

The total length of the line will be 14.8km, of which 9.6km running between the Central Bus Terminals and Zapopan should be opened first for operation. In this case, in consideration of the construction of Route No.3, the conjunction point of Route No.2 should be provided with a side line for direct passage of the trains.

Immediately following the construction of the above seciton, the section of 5.2km between the Central Bus Terminals and Tlaquepaque will be completed. Thus Route No.2 shall have been enitrely completed.

4). Route No.3

Route No.3 will take charge of the transportation covering Prados Vallarta, the west-side district of the city, and the area leading to the center of the city from Oblatos, the north-east district of the city. At present, the railroad passengers at Guadalajara city are very few, however, in future, a high speed mass transportation means should be developed as an inter-city tansit transport. This Route No.3 will be connected with the ground railway station of "Estacion de Pasajeros". This line can expect a large number of commuters along the highly populated area of Hacienda de Huentitan.

The construction of Route No.3 should be commenced from Oblatos section and the subway operation should be opened from the Oblatos-Estacion section. At this stage of operation, Route No.3 should use as its base the side line provided to connect with Route No.2, and also should utilize the train depot of Route No.2.

The following section between Estacion de Pasajeros and Prados Vallarta extending 7.5km length is desirable to be opened for operation together with the above section.

According to the situation, it also may be possible to divide into two sections of Estacion de Pasajeros – Los Arcos, 4.5km long and Los Arcos – Prados Vallarta, and commence the operation at separate times. In such case, the opening of the Estacion des Pasajeros and Los Arcos section should be as early as possible. Upon opening of the entire Route No.3, a train depot and a car-inspection and repair shops are desirable to be provided for use by Route No.3, and the use of direct passage of Route No.2 should be eliminated except in the case of the car-repair necessity.

5). Route No.4

Route No.4 will cover the transportation of passengers in the residential area of the northern district and the industrial area of the southern district leading to the center of the city. The total length of the line will be 10.4km. The construction of this line should be so planned, if it is possible, as to complete and open the entire line at one time since sufficient experience shall have been acquired through the construction and operation of the earlier opened Route No.1, 2 and 3. However, in case of the necessity of dividing the construction work in two stages, it is advisable that the construction be started first from the section having the length of 7.7km running from the conjunction station with Route No.3 and No.4, near the Moleros park to the industrial area of Lomas de Polanco, where an increasing number of commuters is expected and an appropriate land space for depot is available. After this, the line should be extended to the north, to the Jalisco Studium.

2. Time for completion of the work

Generally the subway construction work is done by the open-cut method whereby the tunnel is made by digging in from the ground surface, and afterward refilling. Consequently, symultaneous initiation of work from all parts of the construction site can be possible. Therefore, there is no such work limitation in the subway construction as in the case of a long tunnel to be cut through a mountaineous terrain where only two ends are possible for digging, or a river bridge construction for which the net workable days depend strictly on weather conditions.

Normally, for the most economic speed of construction, the entire subway line is divided into sections of 500m – 1,000m length, and work is commenced from several such sections at a time if these are projected to be completed for operation in the same time. In this case, the average time requirement for 500m – 1,000m length of subway construction in Tokyo is about 24 – 30 months. But any section expected to require difficult work is divided into short work units of about 300m length so that such units could be completed in about the same period as in the case of the average section.

In this city, however, the subway construction has been projected and is to be carried out at the very appropriate stage of the development of the city having no much difficult obstacles such as the covering of the road surface or suspension of daytime work as in the case of Tokyo. Therefore, it can be expected that the construction work will be completed in much shorter time than it was in Tokyo. Also the construction term for power supply facilities, car-depot and other necessary facilities in connection with the subway project can be within 24 – 30 months. As for the total time requirement including the period for the training of the car-operators, it will be safe to consider a period of about 36 months (3 years).

Table 13-1 indicates, with respect to the respective lines, the work completion terms and the extension of the sections to be opened for operation of the subways in Tokyo after 1951. Table 13-2 indicates the work schedule of subway construction. The work from the excavation to the construction of the tunnel takes the longest period. If one portion of a section is delayed due to difficulty of work, then, certain changes in work unit have to be made so that the whole work will progress uniformly for symultaneous opening for operation.

Table 13-3 shows the work initiation time and the opening time including the section of each line from No.1 to No.4, assuming the entire work will be completed in 10 years.

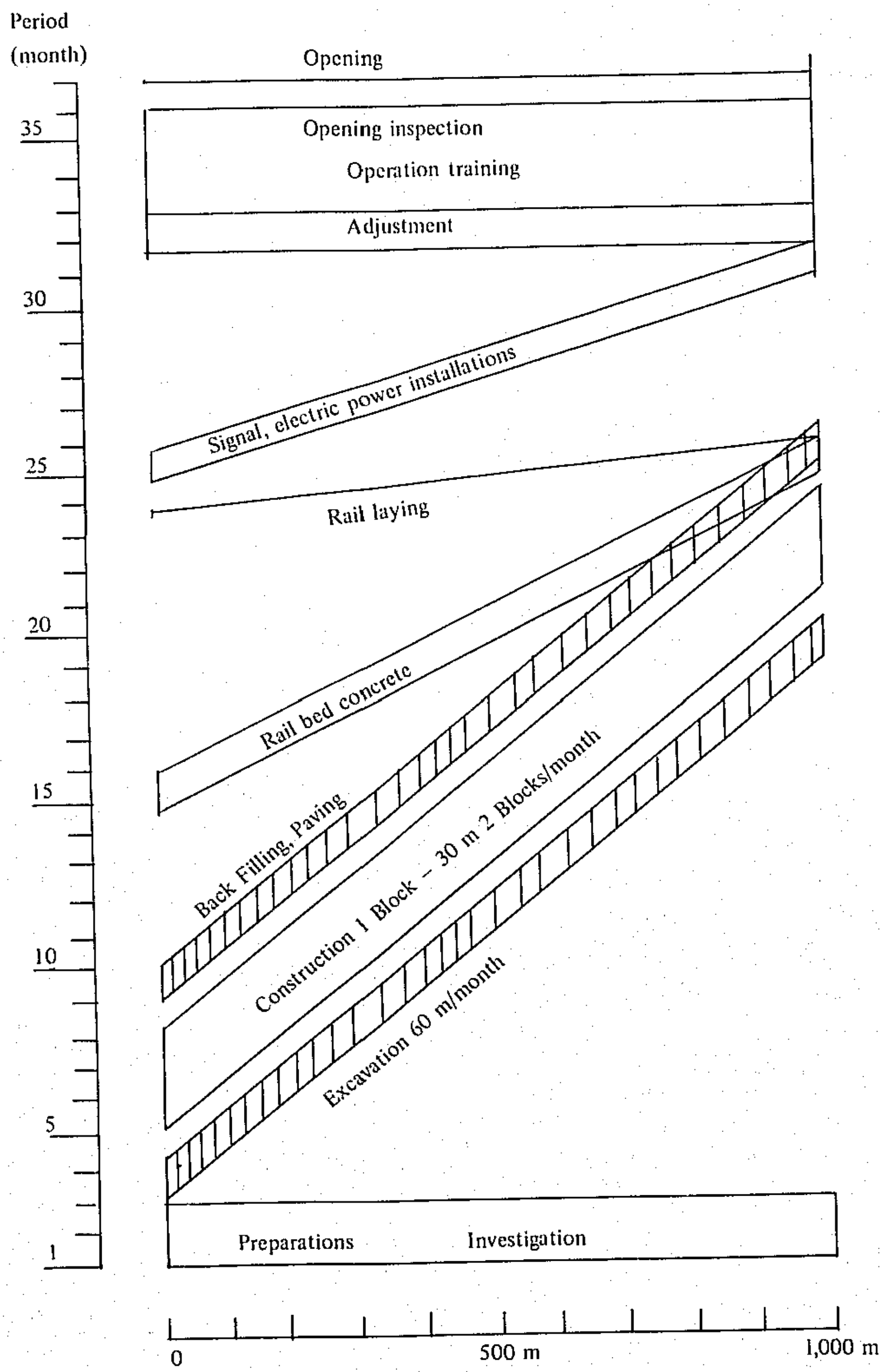
Table 13-1. *Length of Time Required from Initiation of Construction to Opening of Subways in Tokyo*

Line	Section	Length km	Initiation Date	Opening Date	Required Time
Marunouchi	Ikebukuro – Ochanomizu	6.4	1951 Apr.	1954 Jan.	two years ten months
	Ochanomizu – Awajicho	0.8	1954 Aug.	1956 Mar.	one year eight months
	Awajicho – Tokyo	1.5	1954 Aug.	1956 July	two years
	Tokyo – Ginza	1.1	1956 Jan.	1957 Dec.	two years
	Ginza – Kasumigaseki	1.0	1956 Aug.	1958 Oct.	two years three months
	Kasumigaseki –Shinjuku	5.8	1957 Feb.	1959 Mar.	two years two months
	Shinjuku – Shinnakano	3.0	1959 Mar.	1961 Feb.	two years
	Shinnakano – Ogikubo	4.6	1960 Apr.	1962 Jan.	one year ten months
Hibiya	Minamisenju – Nakaokachimachi	3.7	1959 May	1961 Mar.	one year eleven months
	Kitasenju – Minamisenju	2.1	1960 Dec.	1962 May	one year six months
	Nakaokachimachi – Ningyocho	2.5	1960 June	1962 May	two years
	Ningyocho – Higashiginza	3.0	1961 Mar.	1963 Feb.	two years
	Higashiginza – Kasumigaseki	2.0	1962 Sept.	1964 Aug.	two years
	Kasumigaseki – Ebisu	6.0	1961 Oct.	1964 Mar.	two years six months
	Ebisu – Nakameguro	1.0	1963 Feb.	1964 July	one year six months

Table 13-3 Work Schedule for 4 Routes

Route	Section & Length		Term (Year)									
			1	2	3	4	5	6	7	8	9	10
No. 1	First term	9 km	—	—	→							
	Second term	4.6 km		—	—	→						
No. 2	First term	9.6 km			—	—	→					
	Second term	5.2 km				—	—	→				
No. 3	First term	7.5 km					—	—	→			
	Second term	7.5 km						—	—	→		
No. 4	Whole line	10.4 km								—	—	→

Table 13-2 Work Schedule for Track Section (Standard)



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CHAPTER XIV. ESTIMATED CONSTRUCTION COSTS.

As the construction work of a subway is devoted mainly to underground work excavating tunnel work, which, however, is greatly influenced by the geological condition of the area.

In view of the ground condition in Guadalajara district which is generally favorable showing no distinct geological variations, it appears very satisfactory for construction of subways in this area, and as the result, the calculation of the subway construction budget is made based on an open-out method which is assumed as the most appropriate method for this area.

In this city, the public works such as construction and improvement of sewerage, roads, etc. have been performed, and information and data for calculation of construction cost of such works are available. However, these data are only concerned with the works performed 4m – 5m deep underground, and besides the scale of works as well as the types of structures built are essentially different from those of subway construction. Therefore, the costs estimated for this project are based on the similar cases of subway construction in Tokyo.

1). Railway track area

The average excavation depth will be 12m, and in the outskirts of the city, the excacation will be made with 75° gradient, but no earth timbering will be applied, while in the city area, a simple earth retaining will be made.

2) *Station area*

The average excavation depth will be 12m same as the railway track area. As the surface road above the subway line has 30m – 40m in width, and is considered possible to make a total road block to facilitate a large scale excavation. However, for the station area, an extensive excavation is necessary and the excavated space will reach nearly the underneath of the buildings and houses standing on both sides of the road. For this reason, a strong earth sustaining will be applied.

Assuming island type platforms to be used, the railway tracks on both sides of the station will have a wider space each. So this cost for the widened tracks will be included in the station cost.

Cost for tracks will be calculated for concrete rail bed. Cost for electric facilities will be calculated in cosideration of the datas of costruction costs of structures, buildings and tracks.

The construction administrative expenses are generally calculated at the ratio of 6 – 10% against the
The construction administrative expenses are generally calculated at the ratio of 6 – 10% against the construction costs for the fixed facility assets. In this project, however, the medium figure of the above, that in, 8% will be taken. When calculated on the above basis, the civil work cost will be as shown in Table 14-1 and 14–4, and the total construction cost as Table 14–5.

The cost for the cars is calculated based on the number of cars required for the train operation at 2½ minutes intervals which is the technically allowable limitation. However, if the train operation is made at 5 min. intervals during the time of the opening, the sufficient number of cars required for such operation will be 337, the half of total cars in final need.

The forecast of bunget for each year based on the work schedule given in Chapter XIII is as shown in Table 14-6, provided, however, the land cost for space of railway tracks and site for stations has not been included as it seems to amounting to very insignificant figures.

Table 14-1 Construction Cost of Route No. 1

(Unit: ¥1 million)

Classification	Length & No. of Stations	Construction Cost per 1 km or 1 station	Construction Cost
Railway	11.7 km		16,556
Central part of City	4.1	1,480	6,068
Others	7.6	1,380	10,488
Station	1.9 km		5,910
Island type	7	420	2,940
Separate type	9	330	2,970
Total	13.6 km		22,466

Table 14-2 Construction Cost of Route No. 2

(Unit: ¥1 million)

Classification	Length & No. of Stations	Construction Cost per 1 km or 1 station	Construction Cost
Railway	12.9 km		16,726
Central part of City	4.2	1,480	6,216
Others	7.0	1,380	9,660
Elevated section	1.7	500	850
Station	1.9 km		5,170
Island type	3	420	1,260
Separate type	11	330	3,630
Elevated station	2	140	280
Total	14.8 km		21,896

Table 14-3 Construction Cost of Route No. 3

(Unit: Y1 million)

Classification	Length & No. of Stations	Construction Cost per 1 km or 1 Station	Construction Cost
Railway	13.1 km		18,628
Central part of City	5.5	1,480	8,140
Others	7.6	1,380	10,488
Station	1.9 km		6,090
Island type	9	420	3,780
Separate type	7	330	2,310
Total	15.0 km		24,718

Table 14-4 Construction Cost of Route No. 4

Classification	Length & No. of Stations	Construction Cost per 1 km or 1 Station	Construction Cost
Railway	9.1 km		13,098
Central part of City	3.4	1,480	7,992
Others	3.7	1,380	5,106
Station	1.3 km		4,080
Island type	5	420	2,100
Separate type	6	330	1,980
Total	10.4 km		17,178

Table 14-5 Construction Cost of Each Route per Items

(Unit: ¥1 million)

Classification	Route No. 1	Route No. 2	Route No. 3	Route No. 4	Total
	13.6 km	14.8 km	15.0 km	10.4 km	53.8 km
Cost of:					
Structure works	22,470	21,900	24,720	17,180	86,270
Buildings & interior decoration of stations	480	460	480	330	1,750
Tracks	820	890	900	620	3,230
Electrical equipment	2,380	2,320	2,610	1,810	9,120
Car shed	3,770	2,000	1,850	1,330	8,950
Cars	5,040	5,460	5,670	4,050	20,220
Administrative	2,390	2,200	2,440	1,700	8,730
Total	37,350	35,230	38,670	27,020	138,270

Remarks; Cost of designing is included in both cost of structure works and administrative, totalling about 10% of total cost.

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Table 14-6 Estimated Construction Cost by Chronological Order

(Unit: ¥1 million)

Items			1	2	3	4	5	6	7	8	9	10	Total
Route	Order	Equipment	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	
No. 1	1st term	Final installation	6,600	7,670	8,130								22,400
		Cars			3,300								3,300
	2nd term	Final installation		2,300	4,000	3,610							9,910
		Cars				1,740							1,740
No. 2	1st term	Final installation			5,300	6,900	7,820						20,020
		Cars					3,540						3,540
	2nd term	Final installation				2,600	3,070	4,080					9,750
		Cars						1,920					1,920
No. 3	1st term	Final installation					4,100	5,500	5,980				15,580
		Cars							2,850				2,850
	2nd term	Final installation						4,220	6,100	7,100			17,420
		Cars								2,820			2,820
No. 4		Final installation								5,900	7,940	9,130	22,970
		Cars										4,050	4,050
Grand Total		Final installation	6,600	9,970	17,430	13,110	14,990	13,800	12,080	13,000	7,940	9,130	118,050
		Cars			3,300	1,740	3,540	1,920	2,850	2,820		4,050	20,220
		Total	6,600	9,970	20,730	14,850	18,530	15,720	14,930	15,820	7,940	13,180	138,270

CHAPTER XV. MANAGEMENT PLAN

As it is the general practice throughout the world that most of the public transportation business is managed and operated as an independent enterprise, the management and operation of the subways of Guadalajara City are planned and budgeted as an independently managed enterprise.

1. *Operating cost*

For the calculation of the operation of the operating cost, the basic data should be quoted from the actual labor cost, prices, power cost, etc., however, as it is an overall estimation of the budget, the actual figures taken from the Teito Rapid Transit Authority are adopted as a reference. Table 15-1 represents the actual figures in 1967 of said corporation. The cost of each car-kilometer excluding the amount of depreciation and interest is ¥98.86.

Generally, the increase rate of labor cost is higher than that of the commodity price, but here a 3% of annual increase rate is accounted in the computation of the operating cost.

As part of Route No.1 will open and operate from the fourth year after the commencement of the construction work, the operating cost of a train per kilometer in the fourth year can be computed as follows including the six year increase rate:

¥98.86 x 6 cars = ¥593.16

¥593.16 x 1.1940 (price increase rate) = ¥708.23

During the initial period of the opening, each train should be composed of four cars. However, for convenience sake, the calculation is made based on 6-car train basis.

2. Number of passengers and train kilometers

Based on the figures estimated for 1980, the number of passengers prior to 1980 is calculated at the reduction rate of 7% each year. As to Routes No.1, No.2 and No.3, 10% each is reduced assuming there will be no inductive effect for the first two years of operation.

After 1980, the annual increase rate is expected at 5%. Therefore, the calculation results are as shown in Table 15-2.

As to the computation of train kilometer prior to 1980, the values as sought by making a reduction at the annual rate of 7% per each line from the annually calculated numbers of passengers based on the above method.

After 1980, the average transportation efficiency of 100% will be gradually raised, and in 1988 when it reaches 150%, a 5% increase in transport capacity will be made. At this stage, the train operation will amount to 262 runs per day for one way, which will be almost equivalent to the number of subway runs in Tokyo at present. As the results, it will become difficult to make a large scale increase of trainrunning after 1988, while the transportation efficiency will be gradually raised.

The actual values in Tokyo represents about 220%. Therefore, it is assumed that during the length of 10 years after 1988, the subway will maintain sufficient capacity to handle the increasing number of passengers.

The train kilometer per each year is as shown in Table 15-3. The annual operation cost per each train kilometer as per Table 15-3 is indicated in Table 15-4.

3. Business profit

The factors to decide the business revenue are the fare system and the basic fares. When the transportation distance extends to a long distance, a distance proportion system should be adopted. As the subway transportation is an urban traffic, and most of the cities in the world are using single rate fare for all sections, it may be advisable that this subway also adopts the same fare system which makes it possible to mechanize all wicket business.

In consideration of the above, the single rate of fare for the subway will be ¥30 taking the example of the fares in Tokyo subways.

This ¥30 fare rate at the time of the opening in 1973, which is the fourth year after the commencement of the construction of the subway, will be raised by some 10% after 3 or 4 years of operation following the annual 3% price increase in consideration of the increase in operational expenses with the opening of the rest of the lines one after another.

With the single rate of fares throughout the entire sections of the line, the business revenue account must exclude the estimated number of passengers who interchange the trains since a 10% of the interchanging passengers is included in the calculation of the number of passengers of the trains in each line.

Culculating the business revenue bases on the number of passengers on annual basis as represented in Table 15-2, the figures are as indicated in Table 15-5.

4. Accounting

According to how the finance is raised for this subway project, namely, whether it is an appropriation from a public fund or financed by a loan as a private business, there will be great difference in the interest burden. Assmuing that this is an normal private project, and is managed and operated as such, the entire finance for the project may have to depend on borrowed money.

In such case, the interest rate can be assumed as much as more than 10%, in Guadalajara City however, in view of the public nature of the business as well as the particular significance of railway project, it will be reasonable to find a finance of lower interest rate of some 7% range following the example of Japan or elsewhere.

There are two methods of depreciation. One is the fixed installment method while the other is the constant percentage method. As a whole, most of private enterprises use the latter method. However, following the general practice of railway business in general, this subway will adopt the fixed installement method. The depreciation term will be 50 years for all fixed assets of the facilities, for the generality of the computation, and 13 years for the cars. Consequently, from 13 years after opening of the operation (1985), renewing of cars and, from 1988, purchasing of additional 143 cars to increase the number of operating cars can be considered. Also, the construction cost and the cost of cars will increase at the annual rate of 3% as same in the case of the operating cost.

The profit and loss account based on the above listed figures is as given in Table 15-6, and it indicates an operation in pre-depreciation black after the completion of all lines, while 4 years thereafter, post-depreciation black.

5. Management organization

There will be an organization to manage and operate the construction work during the construction period, and there will be only a limited number of persons required for construction itself. Therefore, after the opening of the business, the size of the organization will naturally expand and enlarge with the expansion of business. The size of the managerial and operational organization of the subway of Guadalajara City can be assumed as indicated roughly in Table 15-8, taking the examples of the organizations of subways in Tokyo into reference.

Table 15–1 Actual Examples of Operational Cost (Tokyo Subway, 1967)

Items of Costs	Cost for 1967	Cost/1km/Car
Train kilometer	91,017,540	1 km
Labor expenses	¥5,479,795,184	¥ 60.21
Expenses for:	3,124,563,016	34.33
Breakdown		
Track maintenance	361,740,796	3.97
Electric circuit maintenance	215,330,801	2.37
Car maintenance	546,563,238	6.01
Operating & transporting	531,160,100	5.84
Electric power for train	915,840,949	10.06
Maintenance & administration	79,627,314	0.874
Transport management	29,861,458	0.328
Car rent	383,502,824	4.21
Head office	60,935,536	0.669
Others (taxes, etc.)	393,514,567	4.32
Total operational cost		98.86
K.W.H	227,325,020	2.498

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Table 15–2 Estimated Number of Persons Transported per Year

Chronological order	4	5	6	7	8	9	10	11
	1973	1974	1975	1976	1977	1978	1979	1980
(1,000 persons/day)								
No. 1 line	127	274	329	352	381	410	443	477
No. 2 line			166	359	432	464	502	540
No. 3 line					174	374	450	484
No. 4 line								413
Total	127	274	495	711	987	1,248	1,395	1,914
(1 million persons)								
No. of persons transported/year	46	100	180	259	360	455	509	698

Chronological order	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
(1000 person/day)														
No. of persons transported	2,009	2,109	2,214	2,324	2,440	2,562	2,690	2,824	2,965	3,113	3,268	3,431	3,602	3,782
(1 million persons)														
No. of persons transported/year	733	769	808	848	890	935	981	1,030	1,082	1,136	1,192	1,252	1,314	1,380

Note: Calculation was made down to 3 places of decimals and figures below decimal point are omitted in the Table.

Table 15–3 Estimated Train Kilometers by Chronological Order

Chronological order		4 1973	5 1974	6 1975	7 1976	8 1977	9 1978	10 1979	11 1980
Route No 1	Business k.m.	9.0	13.6	13.6	13.6	13.6	13.6	13.6	13.6
	One way								
	No. of trains/day	147	159	172	185	199	214	231	249
	Train k.m./day	2,646	4,324	4,678	5,032	5,412	5,820	6,283	6,773
Route No. 2	Business k.m.			9.6	14.8	14.8	14.8	14.8	14.8
	One way								
	No. of trains/day			172	185	199	214	231	249
	Trains k.m./day			3,302	5,476	5,980	6,334	6,837	7,370
Route No. 3	Business k.m.					7.5	15.0	15.0	15.0
	One way								
	No. of trains/day					199	214	231	249
	Train k.m./day					2,985	6,420	6,930	7,470
Route No. 4	Business k.m.								10.4
	One way								
	No. of trains/day								249
	Train k.m./day								5,179
Train k.m. per day total		2,646	4,324	7,980	10,508	14,287	18,574	20,050	26,792
Annual train k.m. (1000 km)		965	1,577	2,912	3,835	5,214	6,779	7,318	9,779

Chronological order	12 1981	13 1982	14 1983	15 1984	16 1985	17 1986	18 1987	19 1988	20 1989	21 1990	22 1991	23 1992	24 1993	25 1994
Train k.m./day	26,792	26,792	26,792	26,792	26,792	26,792	26,792	28,133	28,133	28,133	28,133	28,133	28,133	28,133
Annual train k.m. (1000 km)	9,779	9,779	9,779	9,779	9,779	9,779	9,779	10,268	10,268	10,268	10,268	10,268	10,268	10,268

Table 15-4 Operating Cost by Chronological Order

Chronological Order	4 1973	5 1974	6 1975	7 1976	8 1977	9 1978	10 1979	11 1980	12 1981	13 1982	14 1983	15 1984	16 1985	17 1986
Annual train k.m. (1,000 km)	965	1,577	2,912	3,835	5,214	6,779	7,318	9,779	9,779	9,779	9,779	9,779	9,779	9,779
Operating cost/train 1 k.m. (Yen)	709	730	752	774	797	821	846	871	898	925	952	981	1,010	1,041
Operating cost (¥1 million)	684	1,151	2,189	2,968	4,155	5,565	6,191	8,517	8,781	9,045	9,309	9,593	9,876	10,179

Chronological Order	18 1987	19 1988	20 1989	21 1990	22 1991	23 1992	24 1993	25 1994
Annual train k.m. (1000 km)	9,779	10,268	10,268	10,268	10,268	10,268	10,268	10,268
Operating cost/train 1 k.m. (Yen)	1,072	1,104	1,137	1,171	1,206	1,243	1,280	1,318
Operating cost (¥1 million)	10,483	11,335	11,674	12,023	12,383	12,763	13,143	13,533

Table 15-5 Estimated Business Revenue by Chronological Order

Chronological Order	4 1973	5 1974	6 1975	7 1976	8 1977	9 1978	10 1979	11 1980	12 1981	13 1982	14 1983	15 1984	16 1985	17 1986
No. of persons transported/ year (1 million)	46	100	* 180	259	360	455	509	698	733	769	808	848	890	925
Fares (Yen)	30	30	30	30	33	33	33	36	36	36	40	40	40	40
Annual business revenue (¥1 million)	1,380	3,000	4,860	6,993	10,692	13,513	15,117	22,615	23,749	24,915	29,088	30,528	32,040	33,660

Chronological Order	18 1987	19 1988	20 1989	21 1990	22 1991	23 1992	24 1993	25 1994
No. of persons transported/ year (1 million)	981	1,030	1,082	1,136	1,192	1,252	1,314	1,380
Fares (Yen)	45	45	45	45	50	50	50	55
Annual business revenue (¥1 million)	39,730	41,715	43,821	46,008	53,640	56,340	59,130	68,310

Note: * -- After this year the business revenue is calculated for 10% reduced number of passengers as 10% corresponds to transferring passengers.

Table 15-6 Estimated Profit and Loss

(Unit : ¥ 1 million)

Chronological order	1 1970	2 1971	3 1972	4 1973	5 1974	6 1975	7 1976	8 1977	9 1978	10 1979	11 1980	12 1981	13 1982	14 1983
Income:														
Business revenue	0	0	0	1,380	3,000	4,860	6,990	10,690	13,510	15,110	22,610	23,740	24,910	29,080
Expenditure:														
Operating cost				680	1,150	2,180	2,960	4,150	5,560	6,190	8,510	8,780	9,040	9,300
Depreciation				1,020	1,550	2,640	3,220	4,140	5,130	5,130	6,580	6,580	6,580	6,580
Interest on borrowing				2,030	2,980	4,950	5,960	7,600	9,450	9,450	12,080	12,080	12,080	12,080
Total of expenditures	0	0	0	3,730	5,680	9,770	12,140	15,890	20,140	20,770	27,170	27,440	27,700	27,960
Profit and loss account	0	0	0	-2,350	-2,680	-4,910	-5,150	-5,200	-6,630	-5,660	-4,560	-3,700	-2,790	1,120

Chronological order	15 1984	16 1985	17 1986	18 1987	19 1988	20 1989	21 1990	22 1991	23 1992	24 1993	25 1994
Income:											
Business revenue	30,520	32,040	33,660	39,730	41,710	43,820	46,000	53,640	56,340	59,130	68,310
Expenditure:											
Operating cost	9,590	9,870	10,170	10,480	11,330	11,670	12,020	12,380	12,760	13,140	13,530
Depreciation	6,580	6,580	6,860	7,020	7,350	8,800	9,080	9,370	9,370	9,800	9,800
Interest on borrowing	12,080	11,500	11,150	10,450	9,540	8,840	7,580	6,040	3,590	1,350	0
Total of expenditures	28,250	27,950	28,180	27,950	28,220	29,310	28,680	27,790	25,720	24,290	23,330
Profit and loss account	2,270	4,090	5,480	11,780	13,490	14,510	17,320	25,850	30,620	34,840	44,980

Table 15-7 Plan for the Fund

(Unit: ¥1 million)

	Chronological order	1 1970	2 1971	3 1972	4 1973	5 1974	6 1975	7 1976	8 1977	9 1978	10 1979	11 1980	12 1981
Procurement	Profit and Loss	0	0	0	-2,350	-2,680	-4,910	-5,150	-5,200	-6,630	-5,660	-4,560	-3,700
	Depreciation allowance	0			1,020	1,550	2,640	3,220	4,140	5,130	5,130	6,580	6,580
	Borrowing	6,840	11,200	24,100	19,200	24,000	22,300	22,100	22,800	13,200	20,600		
	Amount carried forward	0	10	80	100	170	50	80	90	120	90	100	160
	Total	6,840	11,210	24,180	17,970	23,040	20,080	20,250	21,830	11,820	20,160	2,120	3,040
Expenditure	Construction cost (fixed equipment)	6,600	10,260	18,480	14,310	16,860	15,980	14,420	15,980	10,050	11,910		
	Cost for cars			3,500	1,900	3,980	2,220	3,400	3,460		5,280		
	Borrowing repaid											1,000	2,000
	Interest on borrowing	230	870	2,100	1,590	2,150	1,800	2,340	2,270	1,680	2,870	960	890
	Total	6,830	11,130	24,080	17,800	22,990	20,000	20,160	21,710	11,730	20,060	1,960	2,890
Amount carried over to next term		10	80	100	170	50	80	90	120	90	100	160	150
Balance of borrowing		6,840	18,040	42,140	61,340	85,340	107,640	129,740	152,540	165,740	186,340	185,340	183,340

Table 15-7 (Cont'd)

13 1982	14 1983	15 1984	16 1985	17 1986	18 1987	19 1988	20 1989	21 1990	22 1991	23 1992	24 1993	25 1994
–2,790	1,120	2,270	4,090	5,480	11,780	13,490	14,510	17,320	25,850	30,620	34,840	44,980
6,580	6,580	6,580	6,580	6,860	7,020	7,350	8,800	9,080	9,370	9,370	9,800	9,800
150	190	350	150	680	230	180	510	830	140	360	600	25,900
3,940	7,890	9,200	10,820	13,020	19,030	21,020	23,820	27,230	35,360	40,350	45,240	80,680
			5,140	2,790	5,850	10,510	4,990	5,090		7,750		
3,000	7,000	9,000	5,000	10,000	13,000	10,000	18,000	22,000	35,000	32,000	19,340	
750	540	50										
3,750	7,540	9,050	10,140	12,790	18,850	20,510	22,990	27,090	35,000	39,750	19,340	0
190	350	150	680	230	180	510	830	140	360	600	25,900	80,680
180,340	173,340	164,340	159,340	149,340	136,340	126,340	108,340	86,340	51,340	19,340	0	

Table 15-8 Management Organization

(Grand total 4,400)

Head Office 440	General Affairs Dept. (Planning, General Affairs)		80
	Personnal Detp. (Personal Affairs, Welfare)		80
	Accounting Dept. (Accounting, Materials)		85
	Business Dept. (Business, Statistics)		40
	Operation Dept. (Operation, Cars)		50
	Engineering Dept. (Maintenance of Tracks, Electricity)		105
Field 3,960	Station Business Section—Stations		1,550
	Operation Section - Operation Control Room		40
	Trainmen Section	Drivers	500
		Conductors	530
	Equipment Section	Maintenance of Tracks	280
		Tracks	140
		Communication, Signal	150
		Transformer Section	40
		Inspection Section	390
		Factory	340

CHAPTER XVI SUBWAY SYSTEMS IN SEVERAL CITIES OF THE WORLD

1. New York

New York has a subway system that is longest in the world of today. It has a population of 7,800,000 people living within its boundaries. Manhattan, the center of New York, has a population of 1,560,000 and skyscrapers rising side by side along the streets and avenues. Other boroughs of Bronz, Queens and Brooklyn also have a population larger than that of Manhattan. The city has 35 lines of rapid-transit railways with a total length of 381 kilometers, of which 216 kilometers run in underground tunnels and 18 kilometers are elevated above the streets.

This city's first elevated railway was built in the latter half of the 19th century. Most of the elevated railways went out of existence since 1904 when the city's first subway line was built along the Fourth Avenue of Broadway. Only a small part of the previously built elevated railways is existent at the present time. The subways in New York were built mainly by such private railway companies as IRT (Inter-borough Rapid Transit Company) and BMT (Brooklyn Manhattan Transit). They were in 1940 brought under the control of the New York Transport Department, which had already been operating the IND (Independent) subway network. As a result, the IND and three subway networks were placed under the management of the public transport authority. The New York Transport Department took over tramways, bus and trolley-bus services one after another. In 1953 the Transport Department was reorganized into the New York City Transport Corporation so that coordinated efforts might be made for the operation, maintenance, improvement and expansion of the city's transport network. However, the lack of coordination of the early days is still existent at many places to make the transport system of this city of today so complicated and inconvenient for the passengers.

The subway system has 493 stations that are spaced 800 meters on the average and carries about 1,360 million passengers a year. It uses the system of charging only one fare, 25 cents, for any length of journey and is paid by using a token bought by the passenger. The subway lines consist of double tracks, three tracks or double double-tracks. A fairly large portion of the subway lines have double double-tracks and operate express trains. On the three-track line, one track is used for operating express trains bound for south during the morning rush hours and for running express trains bound for north during the evening rush hours. The subway line has a gauge of 1,435mm. A rail weighs 49.6kg/m. The minimum curve radius of the railway track is 107m.

At a peak of traffic rush 34 trains are operated an hour. An accommodation train that stops at every station is composed of 10 cars and an express train has 11 cars. A subway station has the booking office and ticket gates on a floor halfway between the street above and the platforms below. As many as 92 stations have escalators or elevators to carry passengers between the booking hall and the platform. Most of the subway tunnels were built by using the cut-and-cover technique and have a square cross section. The first double-track subway tunnel was opened in 1904. It is 7.96 meters wide and its height from the surface of the tracks to the ceiling is 3.89 meters and there are pillars in the center. Various different types of tunnels are running under the East River. In 1930 the tunnel lining of ferro-concrete, which was cheaper than cast iron, was used for the first time.

The subway platforms are of various types. At the double-track station the platforms are built in a separate type while an "island" platform is provided at the three-track station where the express train stops. The train operates on 600 V direct current which it receives from the third rail. When the subway lines were operated by private railway companies, they had three power stations of their own. When the Public Corporation took over the subways, it sold the power stations to the Consolidated Edison Company and since then it has been buying electric power from the company.

The subway train cars operating in New York vary in size with the lines according to their former operators, IRT, BMT and IND; the length ranges from 15.56 meters to 20.32 meters and the width from 2.69 meters to 3.06 meters. The largest car of the BMT type has a capacity of carrying 260 passengers, of whom 78 are provided with seats. The New York subway system owns a total of 6,700 cars. The authorized speed of train operation is 35 kilometers per hour for the express and 32 kilometers per hour for the local that stops at each station. The car has four double-doors on each side.

The subways are furnished with automatic electric color-light signaling and the automatic train-stop to ensure safe operation of the trains. An automatically operated train was once in use on the line between the Times Square Station and Grand Central Station, the use of which was discontinued after April 1964 when it caused a fire hazard and proved to be unreliable from the standpoint of safety.

In addition to the above-mentioned three lines of underground railways, New York also has other subway lines such the New Ark Subway running under the Hudson river from New Ark, a city west of New York, to the Hudson Bay Terminal in Manhattan, which uses the "PCC Type" cars that operate on the 600V power collected from the overhead trolley wire, and the 14–kilometer subway owned and operated by the Port Authority

Trans-Hudson Corporation or briefly P.A.T.H. (a public corporation aiming to develop and operate railway transport to link New Jersey State and Manhattan), which runs into the central area of the city through four single-track shield tunnels running under the Hudson River. These subway lines cross each other to form a complicated underground transport network in New York.

The New York Transport Corporation is attempting large-scale expansion of railway routes to cope with the ever-increasing urban traffic habitants and now has completed the work of planning and designing. But the actual work has not yet been started because the American cities generally depend upon the revenue from increased taxes for the funds of construction of a new railway line, and the city council of New York has not yet given approval for the construction of the projected subway lines.

2. Chicago

Chicago is a big city with 3,600,000 population in the middle of the U.S.A., stretching along the south shore of Lake Michigan. It became the center of transport communications by land and water after the construction in 1847 of railroads and later the completion of the Welland Canal allowing ocean-going ships to pass between Lake Erie and Lake Ontario, and grew up as an important market for the harvest of the wheat-lands and other produce of the great prairies of the U.S.A. Chicago of today boasts the greatest industrial output in the U.S.A., especially in machinery and steel.

In Chicago such forms of urban transport as rapid-transit railroads, buses and trolley-buses are operated by the Transit Authority of Chicago. The urban rapid-transit railroads have a total length of 122 kilometers, of which 29.5 kilometers run underground. The elevated type of railroad was first built, which forms a loop in the central area of the city and extends into the west and northwest suburbs. The elevated railroad is carried on steel viaducts above the road level. So, the noise of train operation is so annoying and the road beneath is dark even in the day-time and there is so much auto traffic that the noxius exhaust gases remain stagnant.

The first subway line to be built in this city was the eight-kilometer section of the State Street Line which was completed in 1943. This line runs from north to south along the shore of Lake Michigan and crosses the previously mentioned loop line of rapid-transit railroad so that the passengers can change to and from the elevated railroad at the stations in the intersections. The 6.9-kilometer north-south line of the subway was completed in 1951. The suburban section of this line now extends into the southwest and northwest parts of the city. These two subway lines are connected by underground passages at two stations in the midtown area so that the passengers can easily change between the two lines.

These subway lines all run on the elvated tracks in the suburban districts and some of them have branch lines.

This city's rapid-railway network has 136 stations in total, spaced 800 meters on the average. The underground railroad tunnels run 12 to 15 meters under the ground level. All these tunnels, except a few tube tunnels, were built by the cut-and-cover method. The underground stations on the State Street Line have a long-stretching island platform, and the longest one is 1,067 meters long and 6.7 meters wide so that it would be possible to walk on the platform to the next station. Such a long platform is built also between some other stations. Where there is no such long platform, there is a passage for inspection built on the same level with the platform to link the adjacent stations.

The subway line has a guage of 1,435 millimeters and the minimum curve radius of 73 meters. Electric power to drive the train is collected from the third rail. The train operates on 600V. direct current.

Of the total 1,141 subway cars now in use, 770 are of the P.C.C. type and 180 are airconditioned. The car is 14.7 meters long and its greatest width is 2.85 meters, and has a capacity of 100 passengers and 48 seats. The trains consist of eight cars at most. The maximum frequency of train operations is 33 per hour and the average operating speed is 37.6 kilometers per hour.

The passenger traffic carried by the rapid-transit railroads of this city was about 110 million in 1964.

The subway fare is 25 cents for any length of journey within the city areas and 40 cents for travelling out of the city areas into the suburbs. Both token and transfer ticket are used to pay the railroad fare.

3. Boston

Boston, the capital of Massachusetts State on the east coast of the U.S.A., has the oldest history among American cities. The city's population within its administrative sections such as East Boston and South Boston is about 700,000 but the total population including its neighboring cities such as Cambridge and Charleston amounts to some 2,600,000. These neighboring cities are so close to Boston that they all can be covered by a single network of subways. In this respect Boston resembles the Guadalajara of the future.

The city's rapid-transit railroad network has a total length of 37.3 kilometers, of which 15.2 km run in underground tunnels. In addition, part of street-level railroads is passed in an underground tunnel. In 1898 the first underground railroad in the American Continent was built under Tremont Street. After that, subway lines were built one after another and the network of underground railroads of today were completed by 1924. The unification of the urban transport of this city began in June 1947 when the Metropolitan Transport Authority was created to unify the privately operated elevated railroads and it was reorganized into the Massachusetts Bay Transport Authority efficiently operate the wide-area public transport in and around the city.

There are 41 stations and the average distance between stations is one kilometer, During 1960 the number of passengers carried totalled some 200 million (including the traffic carried by trams and buses). In 1963 the car kilometers by rapid-transit railroads alone amounted to 14,500,000 kilometers. The frequency of train operations during the rush hours was 26 to 27 trains in one direction. A train was composed of 4 cars during the rush hours and 2 cars during the slack hours. The railroad cars have varied passenger accommodating capacities according to the routes, ranging from a minimum of 178 persons (44 seats) to a maximum of 259 persons (56 seats). The scheduled speed of train operation also varies from line to line; 26.6 kilometers per hour for Maine Line, 35.2 kilometers per hour for Cambridge Line, and 30.7 kilometers per hour for East Boston Line.

The railroad has a gauge of 1,435 millimeters. The rails with 42.2 kilograms per meter. The maximum grade is 50 per mill. The minimum curve radius is 122 meters. So, some parts of the railroads have considerably difficult alignment.

The tunnels were built mainly by the cut and cover method and have a square-shaped cross section. The trains operate on 600V. direct current that is collected from the third rail, except one line between Maverick and Wonderland, which uses an overhead wire to receive power.

Boston is an old city and its urban railroads were developed and operated by private companies in the early days. As a result, the present pbulic railroad network include the lines of considerably different performing characteristics. The Metropolitan Transport Authority has been making continuous efforts to improve and expand the city's railroads. It has built new types of rolling stock, adopted an uniform railroad fare system, mechanized the issue and examinations of tickets, increased escalators at the stations, and improved the facilities for the passengers to change from a train to a bus at a terminal station. The railroad network is now serving very satisfactorily the needs of the citizens of this city.
serving very satisfactorily the needs of the citizens of this city.

4. **Philadelphia**

Philadelphia is a city with a population of 2,700,000 inhabitants, situated on the east coast of the U.S.A. Until 1800 it was the seat of the Federal Government and the biggest city in this country. At present Philadelphia ranks fourth in population in the U.S.A. The city has the rich coal and oil fields of Pennsylvania behind it and is blessed with a good harbor in the mouth of the Delaware river that is so deep as to allow the entry of ocean-going vessels. Philadelphia is presently a very important commercial and industrial center in U.S.A.

The city's urban rapid-transit railroad system consists of four routes with an aggregate length of some 47 kilometers, of which about 29 kilometers run underground. The first subway line in this city was the Market Street Line, running from east to west, which was built in 1908. Only the 6.8 kilometers of this line runs underground. Part of a tramway line running along the Market Street is also passed underground. The Market Street Line of the early days and the Frankford Line built in 1922 were constructed and operated by a private company. In 1928 the Broad Street Line was built by the city and its operation was taken over by the private company. This private transport company of Philadelphia is also operating other forms of ground-level transport system such as tramway, bus and trolley-bus. The subway fare is uniformly 25 cents for any length of journey and 22 cents if a token is bought to pay the fare. When the passenger changes to other transport system he or she must pay an additional sum of 5 cents. The passenger traffic carried by the rapid-transit railroad system amounted to some 120 million a year in 1964. The number increases to some 510 million if the numbers of passengers carried by other street-level transport systems such as tramway and bus. There are 58 subway stations, most of them are directly accessible from the office building and shops on the streets. There are many passages and concourses around the city public hall to provide convenient access to the Pennsylvania and other stations.

Two of the four subway routes run through the central city areas from east to west and from north to south, one of the other two lines stretches outward from the city central areas and the other forms a semi-loop line in the central district of the city. The Market Street – Frankford Line has broad gauge of 1,588mm and other lines a standard gauge of 1,435 mm so that there is no interchangeability of trains between these two different types of railroads. The maximum grade of the tracks is 50 per mill. The weight of rail is 44.6 kg/m for the Market Street – Frankford Line and 49.6 kg/m for the other lines. The M–S Line is replacing t-e r ls with the 49.6 kg/m type when the old rails are replaced with new ones.

The railroad tracks are not adequately standardized in many of the cities where urban rapid-transit railroad lines were constructed by several independent companies. It is possible to unify the management and operation of such lines but virtually impossible to standardize the railroad track specifications. So, great care is needed in formulating a plan for building a new railroad transport network.

This city's railroad system has stations spaced 930 meters apart. The scheduled speed is 27.7 km/h for the 27 ss and 25.9 km/h for the local on the Broad Street Line and 32.5 km/h on the Market street Line. A train is composed of 5 to 6 cars. The M – S Line operates trains at intervals of one minute and 45 seconds during the peak of rush hours. The interval is 2 minutes and 45 seconds on the B – S Line. The train length and passenger-carrying capacity are 20.4 meters and 234 persons for the B – S Line and 16.8 meters and 176 persons for the M – F Line. All cars are equipped with a motor. The total number of railroad cars owned is 552.

Since only one railroad fare is charged for any length of journey, the gates to and from the platforms are unattended and are furnished with one-way revolving doors at many stations. The revolving door consists in horizontal bare extending from the floor level up to the ceiling and has the disadvantage of causing a gloomy effect.

The train operates on 600V direct current, receiving power from the third rail, of which there are two types – the upper surface contact type and the lower surface contact type. The automatic color-light signaling system is used.

5. Paris

Paris is known for its well developed subway system built under coherent planning. However, the planning was completed toward the end of the 19th century and the network was completed 35 years ago, the old facilities now have some disadvantages in coping with the vast population of 7,600,000 within the sphere of the city's traffic. So, work is now in progress on the improvement and expansion of the existing subway lines and also on new lines. When the first phase of the new line is completed in the near future, the midtwon section will become accessible directly from the residential district in the west part of the city. There were two different concepts of urban railway at the time when the Paris subway system was projected. One of them was that many railway lines should converge on a city from all directions and the terminuses existing on the circumference of the city should be linked by a subway system. The other way of thinking was that a subway system as a form of urban transport ought to be designed and built with the highest priority to the convenience of the inhabitants of the city.

Paris decided on a subway network best suited to meet the needs of its inhabitants, rejecting the other concept strongly supported by the French National Railways, and completed the first route between Prote de Vincennes and Porte Maillot in 1900. Work on the subway network progressed smoothly and most of the project was completed by 1933. Part of the ancient fortifications around Paris were still remaining in those days and the subway lines did not extend beyond the walls. As the walls were removed around 1930 and the population of inhabitants in the suburban districts increased steadily, work began to extend the subway two or three stations into the suburbs. However, the work of extending the existing subway routes came to a standstill owing to the more-than-expected expansion of the population in the suburban areas and the maintenance of the convenient one-fare system. Thus, Paris now has fifteen subway routes with an aggregate length of 139 kilometers, of which 160 kilometers run in underground tunnels.

In early days both subway and bus services in Paris were created and operated by private companies. In 1921 the many independent bus companies were merged in a single organization. In 1941, the subways and bus services came to an agreement to adjust their competitive relations so that these two different forms of public transport might supplement each other. In 1949, the R.A.T.P. (Régie Autonome des Transports Parisiens) was set up so that Paris's transport might be placed under the control of a single organization.

Paris's subway system has 336 stations spaced 506 meters apart, considerably short compared with the subways in other cities of the world. As the network of subway routes developed more and more, it became possible to close some stations and so far seven stations have ceased to exist, thus considerably helping save the operating cost and speed up the train operation. The subways carried 1,240 million passengers during 1966. Only one fare of one franc is charged for any length of journey. Apart from the ordinary books of ten tickets, each costing 6 franc, Paris subways sell the weekly ticket (Carte Hebdomadaire) on condition that the passenger makes one trip a day, and a variety of cut-rate tickets for large-families, wounded veterans and others, but no ordinary season ticket.

The subway network is so well developed that it is only necessary to walk five minutes or so to reach the nearest station within the city of Paris. All intersections of the subway routes have stations for changing trains. This is very convenient for the passengers but in some places they may find it difficult to know where to change the trains to reach their destinations. So, principal subway stations have an electrically illuminated information board which will show the passenger the shortest route to reach his destination.

All the subway stations have a pair of platforms confronting each other with the railway tracks in between and are so designed to make it very easy for the passenger to change trains. The passenger who has alighted at a junction needs only proceed along the one-way passage having the name of the terminal station of the line to which he wishes to transfer and he will find himself on the right platform without fail. However, this system inevitably has a disadvantage that only one entrance is provided at an end of the platform or the walking distance become unnecessarily long.

The subway tracks have the minimum curve radius of 75 meters, the maximum grade of 40 per mill and a gauge of 1,435 millimeters. The rails weigh 52 kilograms per meter. The tunnels are of the cut-and-cover type or the mountain tunnel type which is lined with arch-shaped masonry and a double-line cross section with no pillars in the center. The station section of the tunnel also has an arch-type construction with no center pillars and you may have a feeling of being oppressed when standing close to the wall of the platform.

The train operates on 600V direct current received from the third rail. The operating speed is 22.6 kilometers per hour, comparatively slow, because the inter-station distances are relatively short, the trains have relatively low accelerating and decelerating performance, the train doors are opened manually by the passengers themselves, not by compressed air under the guard's control, and consequently the train takes a comparatively long time to allow the passengers to get on or off at each station. The train length is 15 meters and the width 2.48 meters. Each train is composed of 4 to 6 cars. During the peak of rush hours, the trains are operated at intervals of one minute and 50 seconds.

It is impossible to cope with the enormous increase in the passenger traffic in Paris only by increasing the capacity of the existing subway lines. Since 1962, work has been in progress on new subway lines which will link with only the principal stations on the existing lines that the suburb-dwellers commuting to work in the midtown areas can travel straight into the center of the city, thus eliminating the need for changing trains at the terminal stations on the existing lines. The projected subway lines will have an aggregate length of 46 kilometers and run through the city from east to west and from north to south. The subway trains will be operated on the national railways lines in the suburban districts. When completed, these new lines will provide very fast transport with a maximum speed of 100 kilometers per hour and an ordinary operating speed of 60 kilometers per hour. For this reason, the maximum grade is less than 30 per mill and the minimum curve radius is 600 meters, a considerably rigid design as the alignment of a subway tracks. Since almost all main streets of Paris already have underground tunnels beneath them, the new subway tunnels must be built under the existing tunnels and this make the new project so much difficult engineering task.

6. **Montreal**

Montreal is Canada's largest city that sprawls in the south part of the Montreal Island in St. Lawrence River. It is linked with New York by the waterways by way of the Great Lakes and Lake Champlaine and with other parts of Canada and the major cities of the U.S.A. by railways. Montreal has developed as an important center of industry and communications by water and land.

There has been a plan for building a subway network in this city since as early as 1910 but the plan had not been put into practice until August 1961 when Mc Jean Drapeau was the mayor of the city. Work on the subway system in Montreal was started in May 1962 under the guidance of Mr. Lucien Saulnier, the chairman of the subway construction committee, and 7-kilometer Route No.1 and 13.9-kilometer Route No.2 were completed in October 1966. So far three subways routes have been built with an aggregate length of 25.6-kilometers.

The construction of Montreal's subways was undertaken by a committee composed mainly of the city's civil-engineering and architecutural engineers assisted by some architects of the city's town planning department and some architects of private architectural designing offices.

Montreal's subways use the type of train with rubber-tire wheels. One of the reasons for using rubber-tire wheels was that the site of the 1967 International Exposition was the Sante-Hélène Island and the subway line had to run under the St. Lawrence River on the north side of the island and the Le Moyne Waterway on the north side, both more than 10 meters deep, and a station was needed on the island and such topographical conditions caused the subway tracks to have steep gradients. Another characteristic feature of Montreal's subways is the use of the car of 2.52 meters wide, small than the 3.15 meters wide that is used widely in the U.S.A. and other countries, in both cases the gauges are standard. The subway system with such a small car width and corresponding small-diameter tunnels occupies a smaller underground space, providing the advantage that the costs of construction of both rolling stock and tunnels are reduced and less time is required for a train to allow the passengers to get on and off at a station. The use of the smaller rolling stock for the subway system is estimated to have reduced the construction cost by as much as 15 per cent. However, there is the danger that it is virtually impossible to conceive any expansion of the subway facilities in case the number of the subway users increases more than expected in the future.

There are a total of 26 stations spaced 701 meters apart. There is only one fare charged for any length of journey and the passenger can change from a subway train to a bus and vice versa. The subways carry 146 million passengers a year. The minimum curve radius of the tracks is 183 meters and the maximum grade is 65 per mill. The rolling stock and tracks are almost the same with those of Paris in construction. The safety and turnout rail have a guage of 1,435 mm and on its outside is a 25.4-centimeter wide steel plate-reinforced concrete runway. Like the rubber tire-subway train of Paris, the Montreal subway coach has eight rubber tired wheels installed horizontally in addition to the regualr rubber tired wheels. Riding on the Montreal subway train, we felt almost no unpleasant feeling caused by sort of rolling from side to side as we felt in the subway train of Paris. This was presmably because of some improvements such as the horizontal rubber tired wheels being positioned 18 centimeters higher and also because the stations have the type of separate platforms and the tracks have good alignment.

The station sections of the subway tunnels were built by the cut-and-cover method, using reinforced concrete or prestressed concrete, and have a square-shaped cross section. The sections between stations were built by boring through rock formations and have an arch-shaped cross section. The two platforms that face each other with the railway tracks in between are linked by a passage leading through the intermediate floor above the station tunnel and below the ground. The booking office and ticket gates are located on the intermediate floor at the downtown subway stations. Suburban stations away from the center of the city have all such facilities on the ground-level premises secured by purchasing privately owned land, with a structural appearance to well harmonize the surroundings.

The subway train operate on 750V. direct current received from the third rail. The motor-coach is 17.2 meters long and the trailer coach 16.42 meters. A train is composed of 6 to 9 coaches. During the peak of rush hours, the trains are operated at intervals of two minutes and 30 seconds. A maximum speed of train operation is 80-kilometers per hour and the scheduled speed is 39-kilometers per hour. Montreal's subway system has a total of 369 coaches.

The construction cost was ¥2,900 million per kilometer, of which 44% was for rolling stock, 5% for land procurement, and 29% for installations, research and so forth.

7. Toronto

Situated on the west shore of Lake Ontario, one of the Great Lake, Toronto is the second largest city in Canada and some 1,800,000 people live within its urban traffic zone. Toronto is an important junction on a transcontinental railroad and a great center of commerce and industry, with a big port with excellent communications by the waterways of the Great Lakes with other parts of Canada and important cities of the U.S.A.

This city is neatly laid out in a rectangular pattern of straight streets intersecting at right angles. The Humber River flows through the city into Lake Ontario. Work on a subway began in 1949 and the Yonge Line was completed in 1954. The existing subway lines have an aggregate length of 26.2 kilometers, of which 23.7-kilometers run through underground tunnels. There are 36 subway stations in total. They are spaced 610 meters apart on the average, comparatively short. Passenger traffic carried by the subway is some 66 million a year. The subway route is divided into zones to charge varying rates of fare according to the distance travelled, 25 cents for one zone and 36.6 cents for two zones. The subway system has a characteristic pattern of routes. There are only two subway lines running through the city. A nearly straight line of 17-kilometers in length runs from east to west under Bloor Street and Danforth Avenue. Another line runs to south and makes a U-turn to north in the downtown area in the center of the city, crossing the straight east-to-west line at right angles. This is not a pattern of lines radiating from one point but the lines are built along the busy main streets of the city.

The railway tracks have a broad guage of 1,495 mm. The railway coach is 22.67 meters long and 3.15 meters wide, fairly large for underground railway rolling stock. No rubber-tired wheel is used. The maximum grade is 34.5 o/oo and the rails weigh 49.6 kilograms per meter.

A train is composed of a widely varying number of cars, ranging from 2 during slack hours to 8 during rush hours. The trains are operated at intervals of 2 minutes and 19 seconds during the peak of rush hours. The scheduled speed is 29 to 32 kilometers per hour. There are two types of platform – the separate and the island types.
the island types.

Most of the subway stations have intermediate floor above the station tunnel and below street level, where there are booking office and ticket gates.

The subway tunnels are of different types such as the ferro-concrete construction of the square cross-section double-line type with center pillars, the double-line mountain tunnel type, and the circular cross-sction type built by the shield tunnelling technique. The stations are also of these three types of construction. There are two stations that are made up with two shield tunnels joined together at the center. The earth covering for the tunnels built by the cut-and-cover method is made so thick as 2.5 meters at least to prevent damage from freezing. The subway train operate on 600V. direct current, which is received from the third rail. In early days the subways in Toronto used 17.5 meter coaches made in Gloucester of Britain but later began to use larger coaches, 22.67 meters long, made by Montreal Rolling Stock Manufacturing Company of Canada. The body of the new type of subway coach is made of aluminum to reduce the weight about 40 per cent. It has four 125 h.p. motors, continuous fluorescent illuminators, thermostat-controlled heaters during the wintertime, and ventilation system consisting of fans with automatic speed controls during the summer season.

The railway signaling is the automatic three-lamp type. Many safety devices are fitted, including automatic train-stop in tunnels and the dead-man's handle in the driver's compartment. The *train is equipped with* a public-address system and a telephone system that enables the driver to talk with the staff of the train traffic control room. A plan for extending the line at two terminuses (5.6 km. and 4.5 km.) was approved in 1964 and presently the construction goes on.

8

APPENDIX

THE INFORMATION & MATERIALS AVAILABLE IN GUADALAJARA FOR REPORT

A– Data For Planning.

1–Mapa de la República Mexicana con la superficie de cada Estado y Su población por los años de 1950, 1960 y estimación a 1970.

2–Mapa del Estado de Jalisco con la división municipal y sus respectivas superficies y población por los años 1950, 1955, 1960, y 1967.

3–Población por ramas de actividad y grupos de edad del Estado de Jalisco y area Metropólitana de Guadalajara por los años 1950, 1955, 1960, 1965, y 1967 con base en los censos oficiales VII y VIII.

4–Plano de incremento de la población.

5–Plano de la Ciudad de Guadalajara, tránsito interior-interior (1:20.000)

6–Plano de la Ciudad de Guadalajara, tránsito interior-interior (1:10.000)

7–Plano de la Ciudad de Guadalajara, puntos de concurrencia de vehículos y personas (1:10.000)

8–Plano de la Ciudad de Guadalajara, puntos de interés turístico (1:2.500)

9–Plano de la Ciudad de Guadalajara aforo de automóviles. (1:2.500)

10–Plano de la Ciudad de Guadalajara aforo de peatones (1:2.500)

11–Plano de la Ciudad de Guadalajara, características viales. (1:2.500)

12–Plano de la Ciudad de Guadalajara, aforos de transportes urbanos. (1:2.500)

13–Plano de la Ciudad de Guadalajara, aforos de tránsito. (1:2.500)

14–Plano de sitios de automóviles. (1:10.000)

15–Plano de la Ciudad de Guadalajara, tránsito exterior-interior (1:10.000)

16–Plano de la Ciudad de Guadalajara, tránsito exterior- proposición. (1:20.000)

17–Plano de la Ciudad de Guadalajara, tránsito exterior-exterior (1:20.000)

18–Plano de la Ciudad de Guadalajara, delimitación de la zona centro. (1:20.000)

19–Plano de la Ciudad de Guadalajara, espacios verdes. (1:10.000)

20–Plano de la Ciudad de Guadalajara, proposición vial, puntos de estudio. (1:20.000)

21–Plano de la Ciudad de Guadalajara, proposición del anillo de circunvalación. (1:20.000)

22–Relación de sitios de autos de alquiler.

23–Plano de la Ciudad de Guadalajara, ubicación de gasolineras y estaciones de servicio. (1:20.000)

24–Plano de la Ciudad de Guadalajara, remodelación de la zona central Etapas 1,2,3, y 4. (1:20.000)

24–Mapa de densidad de población en los años 1955.

26–Movimientos de pasajeros y carga por ferrocarril registrado en las estaciones de los Ferrocarriles Nacionales y del Pacífico en Guadalajara, con los horarios correspondientes.

27–Mapa de las rutas de autobuses en la Ciudad de Guadalajara (No.1 – 7)

28–Planos de la Ciudad de Guadalajara, autobuses urbanos, rutas actuales. (1:20.000)

29–Datos sobre vialidad en Guadalajara y el Estado de Jalisco.

30–Informe sobre los vehículos en circulación desde

31–Plano de la Ciudad de Guadalajara, estudio de tiempo de tardanza (1:20.000)

32–Plano de la Ciudad de Guadalajara, accidentes de tránsito. (1:10.000)

33–Plano de la Ciudad de Guadalajara, proposición del sistema vial. (1:20.000)

34–Organigrama institucional público del area Metropolitana desglosado a niveles federales, estatal y municipal.

35–Monto de salarios, promedio que se paga en las lineas ferroviarias con terminales en la Ciudad de Guadalajara.

36–Salarios en general y por ocupaciones en Guadalajara. Comisión Nacional de los Salarios Mínimos. Salarios mínimos que regirán en los años 1968 – 1969

37–Precios de la tierra catastrales y comerciales en el area Metropolitana.

38–Demografía:

(1) Incremento de la poblacion con números absolutos en los años 1940–1964
(2) Cuadro industrial de Guadalajara 1962
(3) Ocupación.
(4) Agua potable.
(5) Vialidad pasos a denivel en Guadalajara
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(10) *Zonificación.*

B– Technical datas:

39– Plano del Valle de Guadalajara (1:20.000)

40– Fotografía aerea (1:40.000)

41– Plano fotográfico de colectores. (1:20.000)

42– Plano de la Ciudad de Guadalajara, red de gas natural. (1:20.000)

43– Especificaciones generàles de pavimento de concreto de cemento portland y obras complementarias para el fraccionamiento "Jardines de la Paz".

44– Especificaciones generales pavimento de concreto de cemento portland.

45– *Especificaciones generales para pavimento flexible.*

46– Especificaciones generales para pavimento de empedrado.

47– Analisis de precios unitarios de albañileria.

48– Cámara Nacional de la Industria de la Construccion "Delegación Jalisco.

49– Lista de precios unitarios para la *Ciudad* de Guadalajara *y periferia que incluyen materiales, mano de obra y costos indirectos para el año 1968 (1).*

50– Mapa de colectores y Sección de agua y alcantarillado.

C– Data for Planning:

51– Artículos de la ley del servicio de tránsito del Estado, relacionados el transporte masivo.

52– *Plano octavo de los itinerarios de las omnibus de la Empresa Mexicalzingo Mexquitan.*

53– Plano del conjunto de las 122 rutas de omnibus – mostrando movimientos de cantidades de usuarios de los omnibus.

54– Plano de la Ciudad, mostrando la ubicación de las Terminales de los recorridos de los omnibus.

55– Plano del area Metropolitana de Guadalajara *mostrando la ubicación de los sitios en donde se* estacionan los autos de alquiler.

56– Plano de la zona central de Guadalajara (aprox 500 manzanas) mostrando el sentido de la circulación de vehículos y la prelación del paso de éstos de acuerdo con la Ley.

57– Plano de la zona central de Guadalajara, mostrando la intensidad máxima horaria de las calles contenidas.